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ENGINEERING SOIL SAMPLING PLAN FOR CHARACTERIZATION OF THE WELDON SPRING RAFFINATE PITS

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

OCTOBER 1996 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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Revision 0

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Prepared by

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and
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for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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PLAN TITLE: Engineering Soil Sampling Plan for Characterization of the Weldon Spring Raffinate Pits	

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ABSTRACT

The *Engineering Soil Sampling for Characterization of the Weldon Spring Raffinate Pits* will be used to characterize the extent of radiological and chemical contamination in the raffinate pits soils after the debris, sludge, and natural sediments contained in the pits have been removed. The sampling strategies detailed in the plan are based upon topographic information of the bottoms of the raffinate pits, previous characterization of part of the raffinate pits berms, the Record of Decision (ROD) contaminants of concern, and experience of site personnel. Sampling will be phased to correspond with the raffinate pits sludge removal work. Results of the sampling will be used to define the contaminated soil excavation limits necessary to meet the site cleanup standards.

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1 INTRODUCTION

This sampling plan will be used to characterize the extent of radiological and chemical contamination in the raffinate pits 1, 2, 3, and 4 soils after removal of the debris, sludge, and natural organic sediments which resulted from decay of organic matter deposited after construction. The plan is based upon topographic information of the bottoms of the raffinate pits, previous characterization of part of the raffinate pits berms, the *Record of Decision* (ROD) contaminants of concern (COCs), and experience of site personnel.

This sampling plan will be implemented over several years corresponding with the schedule of sludge removal from the raffinate pits. Revisions to the sampling plan will be issued as required to incorporate the information learned from completed sampling, analysis, and data interpretation. A completion report documenting the results and changes to this plan will be written following each sampling phase.

1.1 Purpose

The purpose of characterizing the soil in the raffinate pits is to define the contaminated soil excavation limits necessary to meet the As Low As Reasonably Achievable (ALARA) cleanup goals stated in the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 1).

1.2 Scope

This plan designates sample rationale, locations and depths, sample identification numbers, analytical parameters, equipment, sampling protocols, data review criteria, end use of the data, and quality assurance requirements, including data quality objectives (DQOs).

1.3 Sampling Objectives

The objectives of this sampling plan are to define lateral and vertical extents of raffinate pit soil contamination requiring remediation, which will determine the volume of contaminated soil to be removed from the raffinate pits and placed into the disposal cell. Data from the raffinate pit berms will be used to determine which soils can be used elsewhere (e.g., backfill). To support this objective, this sampling plan will:

- Identify the number of boreholes, borehole locations, and test parameters (Sections 4 through 8).
- Establish sample designation and field sampling procedures (Sections 9 and 10).
- Identify the sample handling and collection procedures (Section 11).
- Identify procedures for data analysis and data management (Section 11).
- Specify quality assurance (QA) requirements (Section 12).

2 GENERAL SITE DESCRIPTION AND HISTORY

2.1 Site Description

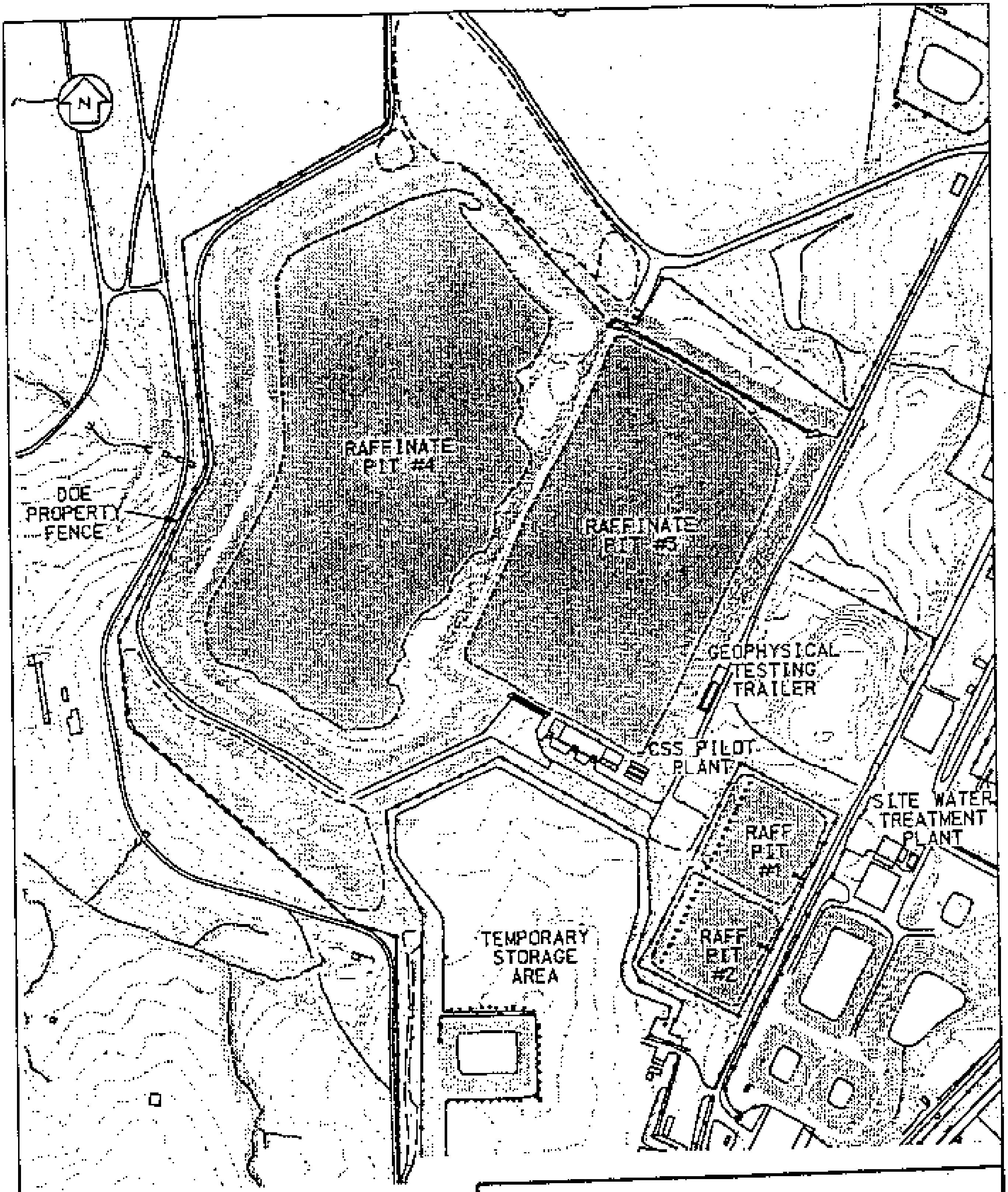
The Weldon Spring site is located in St. Charles County, Missouri, about 48 km (30 mi) west of St. Louis. The 88-ha (217-acre) chemical plant area is located about 3.2 km (2 mi) southwest of the junction of Missouri State Route 94 and Highway 40/61. The site is accessible from State Route 94 and is fenced and closed to the public.

The four raffinate pits are shown on Figure 2-1. Raffinate pits 1 and 2 were constructed with the Uranium Feed Materials Plant in the mid-1950s on the site of the former Weldon Spring Ordnance Works. Raffinate pit 3 was constructed in 1959 to hold additional uranium processing wastes. Raffinate pit 4 was constructed in 1964 to hold wastes from thorium oxides and residues processed at the Uranium Feed Materials Plant. Facility operations ceased in 1967 and limited the amount of sludge that accumulated in Raffinate Pit 4.

Other site features include two former ponds (Ash Pond and Frog Pond) and two former dump areas (North Dump and South Dump). Soil and sludge are radioactively contaminated, and discrete locations also contain elevated concentrations of certain metals and a few organic compounds.

2.2 Site History

The site was initially used by the Army during the 1940s to produce the explosives trinitrotoluene and dinitrotoluene. After extensive demolition, decontamination, and regrading, the chemical plant was built by the U.S. Atomic Energy Commission (AEC) to process uranium and thorium ore concentrates during the 1950s and 1960s. Radioactively and chemically contaminated waste was disposed of at the site during this period. Radioactive contaminants are primarily radionuclides of the natural uranium and Th-232 decay series; chemical contaminants include heavy metals and inorganic anions in excess of naturally occurring background levels, as well as organic compounds such as polychlorinated biphenyls, nitroaromatic compounds, and polynuclear aromatic hydrocarbons.



0 300 600

SCALE FEET

RAFFINATE PITS
SITE PLAN

FIGURE 2-1

REPORT NO.: DOE/OR/21548-653		DRAWING NO.: A/RP/001/0996	
ORIGINATOR: LEJ	DRAWN BY: KSR		DATE: 9/18/96

The *Record of Decision* (ROD) (Ref. 1) for the chemical plant site was signed in 1993. An on-site disposal facility will be constructed.

3 DATA QUALITY OBJECTIVES

3.1 Summary

Development of this sampling plan involves implementation of the data quality objectives (DQOs) process. DQOs are qualitative and quantitative statements that specify the quality of the data required to support decisions during remedial response activities (Ref. 2).

3.2 DQO Development Process

The DQO development process for sampling the soil at the four raffinate pits requires completion of the seven steps (Ref. 2) summarized below. Sections 3.2.1 through 3.2.7 present brief discussions of each step of the DQO development process.

3.2.1 Problem Statement

Currently, there is no information characterizing the depth of soil contamination beneath the sludge in the raffinate pits. Some information characterizing the soil in the raffinate pits berms has been collected and the adequacy of this information has been incorporated into this sampling plan (Ref. 3). Additional characterization of the raffinate pit berms is required. The characterization will be used for determining the volume of contaminated soil to be excavated and placed in the disposal cell and for developing the excavation plans.

3.2.2 Decision Identification

The results of this sampling plan will be used primarily to define excavation cut lines. In addition, data from the raffinate pit berms will be used to determine whether soils require placement in the disposal cell or can be used elsewhere (e.g., backfill material).

3.2.3 Study Inputs

Inputs include:

- Chemical plant ROD contaminants of concern (COCs), identified in Table 3-1, and concentrations in the soil samples collected during sampling.
- For information only, toxicity characteristic leaching procedure (TCLP) (volatiles, semi-volatiles, and metals), Weldon Spring toxicity characteristic leaching procedure (WTCLP), and volatile organic compounds (VOCs) concentrations in soil samples.
- Field scans with a Geiger Mueller 44-9 beta gamma detector of borings from this sampling.
- Results of sampling the raffinate pits berms in late 1995 and early 1996 (Ref. 4).
- Earlier sludge and raffinate pit water characterization.

TABLE 3-1 Chemical Plant ROD Contaminants of Concern for Raffinate Pits Characterization

RADIONUCLIDES	CHEMICAL
Radium-226 (Ra-226) Radium-228 (Ra-228) Thorium-230 (Th-230) Thorium-232 (Th-232) Uranium-238 (U-238)	Arsenic (As) Chromium (Cr) Lead (Pb) Thallium (Tl) Trinitrotoluene (TNT) Polynuclear Aromatic Hydrocarbons (PAHs)[a] Polychlorinated Biphenyls (PCBs)[b]

(a) Benzo (a) anthracene, benzo (b) fluoranthene, benzo (k) fluoranthene, benzo (a) pyrene, and chrysene and ideno (g,h,i-cd) pyrene.

(b) Aroclor 1248, Aroclor 1254, and Aroclor 1260.

3.2.4 Define the Study Boundaries

This sampling plan includes the work areas listed below, in expected chronological order of implementation. The soil in the bottom of the raffinate pits and in the berms will be sampled.

- Raffinate Pit 4 Phase 1, which is the area north of the proposed intermediate dike. Borehole drilling is scheduled to start in 1996 prior to or during the work of Work Package (WP) 471.

- Raffinate Pit 2, which is scheduled to be emptied of sludge in late 1996, characterized, then be available for storage of other site water.

- Raffinate Pit 1, which is scheduled to be emptied of sludge in early 1997, characterized, then be available for storage of other site water.

- Raffinate Pit 3 (future characterization effort may be optimized in a revision to this plan).

- Raffinate Pit 4 Phase 2, which is the sludge impoundment basin inclusive of the intermediate dike (future characterization effort may be optimized in a revision to this plan).

3.2.5 Develop a Decision Rule

The decision as to where to locate the excavation lines for contaminated soil removal will be based on the contaminant concentration levels in the soil and the depth at which the contaminant concentrations exceed As Low As Reasonably Achievable (ALARA) requirements as defined in the ROD. This also includes determining the final disposition of the raffinate pits berm soils.

3.2.6 Develop Uncertainty Constraints

The primary uncertainty constraint associated with this work is that sufficient sampling and analysis be performed so that there is minimal overexcavation (i.e., removal of uncontaminated soil) while minimizing the costs of sampling and analysis. The rationale for dealing with this uncertainty is presented in Section 4. Confirmation sampling will be performed following contaminated soil removal.

3.2.7 Optimizing the Design

The rationale for selecting the number of pit bottom boreholes is presented in Section 4. Borehole locations will be spaced uniformly to represent an equal fraction of the total soil volume to be characterized. However, some additional biased boreholes in both the pit bottoms and the berms will be required. These locations and rationale are as follows:

- Raffinate Pit 4 southeast beach area in order to properly characterize the extent of PCB contamination in the designated PCB area.
- Areas where drums and sludge are known to have been concentrated.
- The raffinate pit berms to supplement previous sampling results.
- Historical water levels will be considered in establishing sampling strategies for the raffinate pit berms.
- Raffinate pit 4 north beach/shelf area where sludge has been located.
- Previous stream features that may exhibit granular material more conducive to contaminant migration.

The exact number and location of additional boreholes are discussed in the corresponding section for each raffinate pit (Sections 5 through 8).

Economic analyses were conducted to evaluate the cost of additional boreholes versus the savings from reduced contaminated soil excavation and disposal costs. Additional boreholes would provide greater accuracy in defining soil excavation limits, and thus reduce the volume of contaminated soil to be excavated.

Estimates of the fill material native-soil interface elevation will be used to approximate the depth of the last sample that will be collected in boreholes on the pit berms; however, a final determination of the interface location will be made by the field geologist present during drilling. The last sample generally will be 1 ft to 2 ft below the interface. Discrete samples (as opposed to composite samples) will be used to better define excavation limits.

Considerations for sample management and sample analysis include the following:

- The basic suite of analyses will be for the COCs listed in the chemical plant ROD as identified in Table 3-1 (Ref. 1); however, contaminants may be considered for elimination from analysis. For additional information only, VOCs, TCLP, and WTCLP will also be analyzed on select samples.

- Boring runs will be scanned with radiation detector instruments to minimize analytical work. Surveying will be performed in an area where low background values will minimize interference with scanning.

- Some samples for metals and radiochemical analyses may be archived for possible future analysis. This may include alternating sample points or specific depth intervals. Those samples to be archived will be defined in the following sections for each pit.

3.2.8 End Use of Data

The data developed from this sampling plan will be used to model contaminant surface contours from which contaminated soil excavation plans will be developed. Backfill or other use plans for raffinate pits berm soils will also be developed.

4 RAFFINATE PITS SAMPLING RATIONALE

4.1 Raffinate Pit Bottoms – Number of Boreholes

The rationale for selecting the number of boreholes to be drilled in a given raffinate pit bottom for sampling and analysis is developed here based on the following assumptions and concepts:

- Contamination in the soil below the sludge is fairly uniform.
- Each borehole represents an equal fraction of the total soil volume to be characterized.
- A variance (V) that relates the number of sampling points to the potential error in over or under excavation of contaminated soil is defined, as a percentage, as follows:

  $$V = 1 / \text{number of boreholes} \times 100$$

- The higher the number of boreholes the greater the accuracy in defining the excavation cut lines; however, there are diminishing returns in increasing the number of boreholes versus the savings in disposal costs associated with the corresponding decrease in V (reduced overexcavation).

For raffinate pits contaminated soil removal, a V value of approximately 11% will be used because this is the contingency value used in establishing the design volumes for raffinate pit soil placement in the disposal cell.

Raffinate Pits 1 and 2 were considered as one unit; Pit 3 and Pit 4 were considered as separate units. For each raffinate pit unit, an array of nine boreholes (V = 11%) will be established. An economic evaluation was conducted that compared the incremental cost of increasing the number of boreholes above nine to the increase in cost associated with the corresponding decrease in V. This economic evaluation is based on the assumption used in the disposal cell design, that 2 ft of contaminated soil will be removed from the raffinate pits after sludge removal is completed.

4.2 Raffinate Pit Bottoms – Borehole Locations and Depths

Borehole locations will be spaced uniformly to represent the fraction of the total soil volume to be characterized. All boreholes will be drilled to auger refusal at the bedrock interface in order to obtain samples from the entire soil depth. Bedrock surface elevations are estimated from Morrison Knudsen Drawing No. 3840D-DC-70234, Bedrock Topography, Rev. B, issued October 29, 1995.

4.3 Raffinate Pit Berms - Number of Boreholes, Borehole Locations, and Depths

Boreholes will be located at the top of the berms beyond the historic high water levels. This will allow characterization of soil that may have been subject to outward migration of contaminants from the raffinate pits.

The soil below the inside slopes of the berms and below the historical high water levels was potentially exposed to downward migration of contaminants. This soil will be characterized by shallow boreholes located on the inner slopes and by deeper inclined boreholes as discussed below.

Additional boreholes will be drilled in Raffinate Pits 3 and 4 to supplement previous sampling data in order to complete the characterization of the berms. Locations of the additional boreholes will be biased, based on the previous sampling. The rationale for selecting the number and location of boreholes to be drilled in Raffinate Pits 1 and 2 berms is identical to the rationale utilized for the raffinate pit bottoms. Specific justification for the number and locations of the new boreholes in the berms will be discussed in the corresponding section for each raffinate pit.

Earlier boreholes drilled at the top of the berms have generally been drilled to a depth elevation of 1 ft to 2 ft below the fill material native-soil interface, as determined by the field geologist present during drilling. New boreholes in the berms will be drilled similarly.

The inside slopes of the berms are generally 2 horizontal to 1 vertical, and are thus too steep for conventional drilling equipment. Therefore, new shallow boreholes on the inner raffinate pit berms will be hand augered. Hand augered boreholes will be restricted to a maximum depth of 9 ft. Inner berm samples from depths greater than 9 ft will be taken using inclined boreholes drilled from the top of the berm. Inclined boreholes drilled from the top of the berm offer a profile of samples from shallow to progressively deeper depths in the soil, below the inner slopes, that were potentially exposed to downward migration of contaminants. Inclined boreholes drilled from the bottom of the pit result in lesser sampling length under the slope than inclined holes drilled from the top of the berm; therefore, they will not be considered at this time. The maximum angle from the vertical for inclined boreholes is 45°. A skid mounted drill rig can be used for drilling inclined boreholes on top of the berms if access is not possible with a truck mounted rig. Based on information from a drilling subcontractor, a minimum of 17 ft of relatively flat surface from the edge of a borehole across the top of a berm is required to accommodate a skid mounted rig. Boreholes in the inner berms will be located at or below the historical high water levels in the pits. The high water elevations for each of the raffinate pits are as follows:

- Raffinate Pits 1 and 2 — 663.0 ft
- Raffinate Pit 3 — 662.5 ft
- Raffinate Pit 4 — 652.0 ft

4.4 Raffinate Pit Boreholes – Sampling Intervals

Borehole cores will be field scanned with a Geiger Mueller 44-9 Beta Gamma detector in an area with a representative low background activity. Instrument background will be used. Scanning will be performed on the soil samples and recorded for future information. Samples will be collected in 1-ft intervals as discrete samples. A 1-ft interval sample requires that the core diameter be 3.75-in. to have sufficient sample in the event the laboratory radiological analyses are performed on site. As indicated in Section 11 (Table 11-1), on-site analysis of radiological components requires 500 g of dry soil. The 1-ft interval vertical bottom samples from the ground surface to 15 ft below the surface will be analyzed for the chemical plant Record of Decision (ROD) contaminants of concern (COCs) identified in Table 3-1. In addition, the first 1-ft to 2-ft interval in each pit bottom vertical boring will be analyzed for volatile organic compounds (VOCs) and the first 1-ft to 2-ft interval from three vertical bottom borings in each raffinate pit will be analyzed by the toxicity characteristic leaching procedure (TCLP). The vertical bottom samples collected below the 15 ft sample will be archived and possibly analyzed pending receipt of results from the upper intervals.

All inclined and vertical berm borehole samples collected will be analyzed in 1-ft intervals for the COCs identified in Table 3-1.

5 RAFFINATE PITS 1 AND 2 SAMPLE LOCATIONS AND PARAMETERS

5.1 General

Raffinate Pits 1 and 2 bottoms and berms will be sampled after the sludge is dredged. The general arrangement of Raffinate Pits 1 and 2 and the approximate borehole locations and depths are shown in Appendix A, Figures A-1 and A-2, respectively. Final coordinates of boreholes will be surveyed following sampling.

The contour lines in Figures A-1 and A-2 represent the clay surface beneath the sludge as presented in the *Raffinate Pit Characterization* report by ECO-Systems (Ref. 5). These contour lines are expected to change to some degree after the sludge is dredged. Pit bottom borehole elevations in this report are preliminary, based on the ECO-Systems contour lines. Final elevations will be surveyed following sampling.

Sample locations are grouped into the following three general categories: (1) vertical boreholes at the raffinate pit bottoms, (2) vertical boreholes at top of the raffinate pit berms, and (3) inclined and vertical boreholes at the raffinate pit berms inner slopes.

Sampling of Raffinate Pit 1 berms was completed in late 1995 and early 1996 per an earlier sampling plan (Ref. 3). Five boreholes, BH-58, BH-59, BH-60, BH-61, and BH-62, located as shown on Figure A-1 were drilled on the outer slope of the north berm to depths ranging from 2.5 ft to 5 ft and top of hole elevations ranging from 653.2 ft to 660.5 ft. The results of the 1995-1996 sampling (Ref. 4) indicate that the samples were only analyzed for Ra-226 and Th-230, and that the only sample that exceeded site cleanup standards was the top 2-ft of BH-58, which had a Th-230 concentration of 10.2 pCi/g. The top of the berms is at elevation 664 ft and the historical high water elevation in Raffinate Pit 1 is 663 ft. Samples will be taken to assess the potential migration of contaminants through the raffinate pit berms. Additional boreholes will be drilled to complete characterization of the top of the west, north, and east berms surrounding Raffinate Pit 1 and to analyze for the other contaminants of concern (COC) identified in Table 3-1. The south berm of Raffinate Pit 1 is common to Raffinate Pit 2.

Sampling of Raffinate Pit 2 berms was completed in late 1995 and early 1996 per an earlier sampling plan (Ref. 3). Two boreholes, BH-63 and BH-64, located as shown on

Figure A-2, were drilled on top of the outer slope of the east berm to a depth of 8 ft. The results of the 1995-1996 sampling (Ref. 4) indicate that the samples were analyzed only for Th-230 and that the site cleanup standard for Th-230 was exceeded with a value of 11.5 pCi/g in the first 1-ft interval of BH-64. The top of the berms is at elevation 664 ft and the historical high water elevation in Raffinate Pit 2 is 663 ft. Samples will be taken to assess the potential migration of contaminants through the raffinate pit berms. Additional boreholes will be drilled to complete characterization of the four sides of the berm surrounding Raffinate Pit 2 and to analyze for the other COCs identified in Table 3-1.

Based on the chemical waste assessment report (Ref. 6), polychlorinated biphenyls (PCBs) were not detected, with a detection limit of 160 μg/kg, in the Raffinate Pit 2 sludge. Semi-volatile contamination was similarly not detected above detection limits. However, in order to have complete characterization, PCBs and polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) will be included as analytes.

Borehole cores will be field scanned with a Geiger Mueller 44-9 Beta Gamma detector in an area with a representative low background activity. Samples will be collected in 1-ft intervals as discrete samples. The 1-ft interval vertical bottom borehole samples from the ground surface to 15 ft below the surface will be analyzed for the chemical plant Record of Decision (ROD) COCs identified in Table 3-1. In addition, the first 1-ft to 2-ft interval in each pit vertical bottom boring will be analyzed for volatile organic compounds (VOCs) and the first 1-ft to 2-ft interval from 1-03, 2-04, and 1-08 will be analyzed by the toxicity characteristic leaching procedure (TCLP). The vertical bottom borehole samples collected below the 15 ft sample will be archived and possibly analyzed pending receipt of results from the upper intervals. All inclined and vertical berm borehole samples collected will be analyzed for the COCs identified in Table 3-1.

5.2 Raffinate Pit 1 Vertical Boreholes

A total of 18 vertical boreholes is proposed (1-01 through 1-05 and 1-11 through 1-23). Of these, five on the relatively flat bottom area and five on top of the berms will be drilled using a drill rig with continuous sampler. Eight holes will be hand augered on the inner slopes of the berms. Sample identifications are given in Table 5-1.

TABLE 5-1 Raffinate Pit 1 Vertical Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
1-01	30	SO-397101-01 Thru SO-397101-30
1-02	29	SO-397102-01 Thru SO-397102 -29
1-03	29	SO-397103-01 Thru SO-397103 -29
1-04	30	SO-397104-01 Thru SO-397104 -30
1-05	29	SO-397105-01 Thru SO-397105 -29
1-11	22	SO-397111-01 Thru SO-397111-22
1-12	22	SO-397112-01 Thru SO-397112-22
1-13	22	SO-397113-01 Thru SO-397113-22
1-14	22	SO-397114-01 Thru SO-397114-22
1-15	22	SO-397115-01 Thru SO-397115-22
1-16	8	SO-397116-01 Thru SO-397116-8
1-17	8	SO-397117-01 Thru SO-397117-08
1-18	8	SO-397118-01 Thru SO-397118-08
1-19	8	SO-397119-01 Thru SO-397119-08
1-20	8	SO-397120-01 Thru SO-397120-08
1-21	8	SO-397121-01 Thru SO-397121-08

TABLE 5-1 Raffinate Pit 1 Vertical Borehole and Sample Identifications (Continued)

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
1-22	8	SO-397122-01 Thru SO-397122-08
1-23	8	SO-397123-01 Thru SO-397123-08

(a) Borehole locations appear in Figure A-1
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

5.2.1 Raffinate Pit 1 Bottom

The five boreholes at the pit bottom (1-01 through 1-05) were spaced uniformly to represent the fraction of the soil volume to be characterized, and each borehole will be drilled approximately 30 ft deep to bedrock elevation of approximately 618 ft.

5.2.2 Raffinate Pit 1 Berms

Five boreholes (1-11 through 1-15) will be drilled at the top of berm at approximately 664 ft elevation. The boreholes are located uniformly at the corners and mid-points of the west, north, and east berms of the pit. These holes will be approximately 22 ft deep to the native-soil fill interface; however, a final determination of the interface location will be made by the field geologist. When the native-soil fill interface is reached, a minimum of two additional 1 ft samples will be collected.

Eight boreholes (1-16 through 1-23) will be hand augered on the inner slopes of the berms to characterize the soil below the inner slope surfaces. The boreholes are located uniformly at the mid-points of the four sides and at the mid-slope of the inner berms.

5.3 Raffinate Pit 1 Inclined Boreholes

A total of six inclined boreholes (1-30 through 1-35) are proposed to characterize the soil below the inner slope surfaces down to points vertically below the bottom of six of the eight hand augered holes. No inclined boreholes are proposed for the top of the south berm because it is too narrow. The geometry and location of the inclined boreholes are shown in Figure A-1. Each inclined borehole will be aligned with its corresponding hand-augered hole. The location of the bottom of each inclined borehole will result in samples approximately 20 ft deep at the slope location. Sample identifications are given in Table 5-2.

TABLE 5-2 Raffinate Pit 1 Inclined Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
1-30	37	SO-397130-01 Thru SO-397130-37
1-31	37	SO-397131-01 Thru SO-397131-37
1-32	37	SO-397132-01 Thru SO-397132-37
1-33	37	SO-397133-01 Thru SO-397133-37
1-34	39	SO-397134-01 Thru SO-397134-39
1-35	39	SO-397135-01 Thru SO-397135-39

(a) Borehole locations appear in Figure A-1
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

5.4 Raffinate Pit 2 Vertical Boreholes

A total of 20 vertical boreholes is proposed (2-01 through 2-04 and 2-11 through 2-26). Of these, four on the relatively flat bottom area and eight on top of the berms will be drilled using a drill rig with continuous sampler. Eight holes will be hand augered on the inner slopes of the berms. Sample identifications are given in Table 5-3.

TABLE 5-3 Raffinate Pit 2 Vertical Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
2-01	30	SO-396201-01 Thru SO-396201-30
2-02	30	SO-396202-01 Thru SO-396202 -30
2-03	30	SO-396203-01 Thru SO-396203 -30
2-04	30	SO-396204-01 Thru SO-396204 -30
2-11	22	SO-396211-01 Thru SO-396211-22
2-12	22	SO-396212-01 Thru SO-396212-22
2-13	22	SO-396213-01 Thru SO-396213-22
2-14	22	SO-396214-01 Thru SO-396214-22
2-15	22	SO-396215-01 Thru SO-396215-22
2-16	22	SO-396216-01 Thru SO-396216-22
2-17	22	SO-396217-01 Thru SO-396217-22
2-18	22	SO-396218-01 Thru SO-396218-22
2-19	8	SO-396219-01 Thru SO-396219-08
2-20	8	SO-396220-01 Thru SO-396220-08
2-21	8	SO-396221-01 Thru SO-396221-08
2-22	8	SO-396222-01 Thru SO-396222-08

TABLE 5-3 Raffinate Pit 2 Vertical Borehole and Sample Identifications (Continued)

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
2-23	8	SO-396223-01 Thru SO-396223-08
2-24	8	SO-396224-01 Thru SO-396224-08
2-25	8	SO-396225-01 Thru SO-396225-08
2-26	8	SO-396226-01 Thru SO-396226-08

(a) Borehole locations appear in Figure A-2

(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

5.4.1 Raffinate Pit 2 Bottom

The four boreholes at the pit bottom (2-01 through 2-04) were spaced uniformly to represent the fraction of the soil volume to be characterized and each borehole will be drilled approximately 30 ft deep to bedrock elevation of approximately 618 ft.

5.4.2 Raffinate Pit 2 Berms

Eight boreholes (2-11 through 2-18) will be drilled at the top of the berm at approximately 664 ft elevation. The boreholes are located uniformly at the corners and mid-points of the four berms of the pit. These holes will be approximately 22 ft deep to the native-soil fill interface; however, a final determination of the interface location will be made by the field geologist. When the native-soil fill interface is reached, a minimum of two additional 1-ft samples will be collected.

Eight boreholes (2-19 through 2-26) will be hand augered on the inner slopes of the berms to characterize the soil below the inner slope surfaces. The boreholes are located uniformly at the mid-points of the four sides and at the mid-slope of the inner berms.

5.5 Raffinate Pit 2 Inclined Boreholes

A total of five inclined boreholes (2-30 through 2-34) is proposed to characterize the soil below the inner slope surfaces down to points vertically below the bottom of five of the eight hand-augered holes. No inclined boreholes are proposed for the top of the north berm because it is too narrow. The geometry and locations of the inclined boreholes are shown in Figure A-2. Each inclined borehole will be aligned with its corresponding hand-augered hole. The location of the bottom of each inclined borehole will result in samples approximately 20 ft deep at the slope location. Sample identifications are given in Table 5-4.

TABLE 5-4 Raffinate Pit 2 Inclined Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
2-30	42	SO-396230-01 Thru SO-396230-42
2-31	42	SO-396231-01 Thru SO-396231-42
2-32	42	SO-396232-01 Thru SO-396232-42
2-33	42	SO-396233-01 Thru SO-396233-42
2-34	42	SO-396234-01 Thru SO-396234-42

(a) Borehole locations appear in Figure A-2

(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

6 RAFFINATE PIT 3 SAMPLE LOCATIONS AND PARAMETERS

6.1 General

Raffinate Pit 3 bottom and berms will be sampled after the sludge is dredged. The general arrangement of Raffinate Pit 3 and the approximate borehole locations and depths are shown in Figure A-3 in Appendix A. Final coordinates of boreholes will be surveyed following sampling.

The contour lines in Figure A-3 represent the clay surface beneath the sludge as presented in the *Raffinate Pit Characterization* report by ECO-Systems (Ref. 5). These contour lines are expected to change to some degree after the sludge is dredged. Pit bottom borehole elevations in this report are preliminary, based on the ECO-Systems contour lines. Final elevations will be surveyed following sampling.

Sample locations are grouped into the following three general categories: (1) vertical boreholes at the raffinate pit bottom, (2) vertical boreholes at top of the raffinate pit berms, and (3) inclined and vertical boreholes at the raffinate pit berms inner slopes.

Sampling of Raffinate Pit 3 berms was completed in late 1995 and early 1996 per an earlier sampling plan (Ref. 3). Forty boreholes, located as shown on Figure A-3, were drilled on top of the berms to the depths indicated on Figure A-3. A summary was prepared from the results of the 1995-1996 sampling (Ref. 4) indicating the boreholes where the site Record of Decision (ROD) soil cleanup standards were exceeded. This summary is shown in Table 6-1.

Borehole cores will be field scanned with a Geiger Mueller 44-9 Beta Gamma detector in an area with a representative low-background activity. Samples will be collected in 1-ft intervals as discrete samples. The 1-ft interval vertical bottom borehole samples from the ground surface to 15 ft below the surface will be analyzed for the chemical plant ROD contaminants of concern (COC) identified in Table 3-1. In addition, the first 1-ft to 2-ft interval in each pit vertical bottom boring will be analyzed for volatile organic compounds (VOCs) and the first 1-ft to 2-ft interval from 3-03, 3-04, and 3-08 will be analyzed by the toxicity characteristic leaching procedure (TCLP). The vertical bottom borehole samples collected below the 15 ft sample will be archived and possibly analyzed pending receipt of results from the upper intervals. All inclined and vertical berm borehole samples collected will be analyzed for the COCs identified in Table 3-1.

TABLE 6-1 Raffinate Pit 3 Berm 1995-1996 Boreholes Exceeding ROD Cleanup Standards

BOREHOLE LOCATION ID	CONTAMINANTS OF CONCERN EXCEEDING CRITERIA OR GOAL	DEPTH OF SAMPLE EXCEEDING CRITERIA OR GOAL (ft)	MAX. DEPTH SAMPLED (ft)	COMMENTS
BH-32	Th-230 = 17.4 pCi/g	0 - 1	23	Exceeds Criteria
BH-34	Th-230 = 16.5 pCi/g	0 - 1	32	Exceeds Criteria
BH-35	Th-230 = 23.4 pCi/g	0 -1	31	Exceeds Criteria
BH-37	Th-230 = 13.2 pCi/g	0 - 5	29	Exceeds Criteria
BH-39	U-238 = 31.2 pCi/g	20 - 25	28	Exceeds ALARA
BH-54	Th-230 = 9.1 pCi/g	5 - 6	7	Exceeds Criteria
BH-125	PAH = 1.6 mg/kg	0 - 5	19	Exceeds ALARA

Characterization of the top of the west, north, and east berms of Raffinate Pit 3 was determined to be adequate. This is based on a sufficient number of boreholes sampled to an adequate depth, as illustrated in Figure A-3. Also, an examination of Table 6-1 indicates that in all cases where a sample exceeded the soil cleanup standards, deeper samples were collected which did not exceed the soil cleanup standards.

Since the top of the berms is at approximate elevation 663.5 feet and the historical high water elevation in Raffinate Pit 3 is 662.5 ft, samples will be taken to assess the potential migration of contaminants through the raffinate pit berms. However, since only one borehole (BH-94) was drilled earlier on the south berm, additional boreholes will be drilled to complete characterization of the south berm.

6.2 Raffinate Pit 3 Vertical Boreholes

A total of 19 vertical boreholes is proposed (3-01 through 3-09 and 3-11 through 3-20). Of these, nine on the relatively flat bottom area and two on top of the berms will be drilled using a drill rig with continuous sampler. Eight holes will be hand augered on the inner slopes of the berms. Sample identifications are given in Table 6-2.

TABLE 6-2 Raffinate Pit 3 Vertical Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
3-01	30	SO-399301-01 Thru SO-399301-30
3-02	36	SO-399302-01 Thru SO-399302-36
3-03	34	SO-399303-01 Thru SO-399303-34
3-04	38	SO-399304-01 Thru SO-399304-38
3-05	37	SO-399305-01 Thru SO-399305-37
3-06	35	SO-399306-01 Thru SO-399306-35
3-07	37	SO-399307-01 Thru SO-399307-37
3-08	37	SO-399308-01 Thru SO-399308-37
3-09	35	SO-399309-01 Thru SO-399309-35
3-11	22	SO-399311-01 Thru SO-399311-22
3-12	22	SO-399312-01 Thru SO-399312-22
3-13	8	SO-399313-01 Thru SO-399313-08

TABLE 6-2 Raffinate Pit 3 Vertical Borehole and Sample Identifications (Continued)

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
3-14	8	SO-399314-01 Thru SO-399314-08
3-15	8	SO-399315-01 Thru SO-399315-08
3-16	8	SO-399316-01 Thru SO-399316-08
3-17	8	SO-399317-01 Thru SO-399317-08
3-18	8	SO-399318-01 Thru SO-399318-08
3-19	8	SO-399319-01 Thru SO-399319-08
3-20	8	SO-399320-01 Thru SO-399320-08

(a) Borehole locations appear in Figure A-3
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

6.2.1 Raffinate Pit 3 Bottom

The nine boreholes at the pit bottom (3-01 through 3-09) were spaced uniformly to represent the fraction of the soil volume to be characterized and will be drilled approximately 30 ft to 38 ft deep to bedrock elevation of approximately 610 ft to 615 ft.

6.2.2 Raffinate Pit 3 Berms

Two boreholes (3-11 and 3-12) will be drilled at the top of berm at approximately 662 ft elevation. The boreholes are located on the south berm, and positioned so as to complete the characterization of this berm. These holes will be approximately 22 ft deep to the native-soil fill interface; however, a final determination of the interface location will be made by the field geologist. When the native-soil fill interface is reached, two additional 1-ft samples will be collected.

Eight boreholes (3-13 through 3-20) will be hand augered on the inner slopes of the berms to characterize the soil below the inner slope surfaces. The boreholes are located uniformly at the corners, mid-points of the four sides, and at the mid-slope of the inner berms.

6.3 Raffinate Pit 3 Inclined Boreholes

A total of four inclined boreholes (3-30 through 3-33) is proposed to characterize the soil below the inner slope surfaces down to points vertically below the bottom of four of the eight hand-augered holes. No inclined boreholes are proposed for the top of the north berm because it is too narrow. The geometry and locations of the inclined boreholes are shown in Figure A-3. Each inclined borehole will be aligned with its corresponding hand-augered hole. The location of the bottom of each inclined borehole will result in samples approximately 24 ft to 26 ft deep at the slope location. Sample identifications are shown in Table 6-3.

TABLE 6-3 Raffinate Pit 3 Inclined Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
3-30	43	SO-399330-01 Thru SO-399330-43
3-31	43	SO-399331-01 Thru SO-399331-43
3-32	43	SO-399332-01 Thru SO-399332-43
3-33	43	SO-399333-01 Thru SO-399333-43

(a) Borehole locations appear in Figure A-3
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

7 RAFFINATE PIT 4-PHASE 1 SAMPLE LOCATIONS AND PARAMETERS

7.1 General

Raffinate Pit 4 Phase 1 sampling will be in the area north of the proposed intermediate dike, possibly before and after the sludge and natural sediments are removed from this area and transferred to the sludge impoundment basin south of the intermediate dike. Construction of the intermediate dike and sludge and sediment removal are within the scope of work of Work Package (WP) 471. The general arrangement of Raffinate Pit 4 and the approximate borehole locations and depths for Phase 1 work are shown in Appendix A, Figure A-4. Final coordinates of boreholes will be surveyed following sampling.

The contour lines in Figure A-4 represent the clay surface beneath the sludge and natural sediments as presented in the *Raffinate Pit Characterization* report by ECO-Systems (Ref. 5). These contour lines are expected to change to some degree after the sludge and natural sediments removal operations of WP-471. Pit bottom borehole elevations in this report are preliminary, based on the ECO-Systems contour lines. These preliminary elevations will be confirmed and revised as necessary based on the as-built survey of WP-471. Final elevations will be surveyed following sampling.

Sample locations are grouped into the following three general categories: (1) vertical boreholes at raffinate pit bottom, (2) vertical boreholes at raffinate pit top of berms, and (3) inclined and vertical boreholes at raffinate pit berms inner slopes.

The northeast land mass of Raffinate Pit 4 was sampled October 17, 1994. Five 1-ft deep samples were taken and identified as SO-294384 through SO-294388. Each sample was analyzed for metals and radiological contaminants. Results of this sampling (Ref. 7) indicate that each sample had at least one contaminants of concern (COC) exceeding the chemical plant Record of Decision (ROD) cleanup standards (Ref. 1). The sampling points are shown on Figure A-4.

Sampling of sediments from exposed beach areas of Raffinate Pit 4 was conducted in February of 1996, (Sample Numbers C465 - C476). The sampling indicated that in all cases, polychlorinated biphenyls (PCBs) were less than 1 mg/kg, metals were below the potential to exceed toxicity characteristic leaching procedure (TCLP) values, semivolatiles were below detection limits, and volatile organic analysis (VOAs) were all below detection limits except acetone (0.16 mg/kg). The sampling also concluded that there is no indication of *Toxic Substance Control Act* (TSCA) or *Resource Conservation Recovery Act* (RCRA) characteristic contaminants at regulated levels within the black or brown sediments located along the exposed beach areas of Raffinate Pit 4.

Sampling of Raffinate Pit 4 berms was completed in late 1995 and early 1996 per an earlier sampling plan (Ref. 3); the sampling points are shown on Figure A-4. The sampling points in the berm common to Raffinate Pits 3 and 4 are considered as part of Raffinate Pit 3, and are shown on Figure A-3. Based on the results of the 1995-96 sampling (Ref. 4) a summary indicating the boreholes where the chemical plant Record of Decision (ROD) soil cleanup standards (Ref. 1) were exceeded was prepared and appears in Table 7-1. These results are discussed in Section 7.2.2.

TABLE 7-1 Raffinate Pit 4 Berm 1995-1996 Boreholes Exceeding Chemical Plant Record of Decision Cleanup Standards

BOREHOLE LOCATION ID	CONTAMINANTS OF CONCERN EXCEEDING CRITERIA OR GOAL	DEPTH OF SAMPLE EXCEEDING CRITERIA OR GOAL (ft.)	MAX. DEPTH SAMPLED (ft.)	COMMENTS
BH-102	Lead = 497 mg/kg	10-15	23	Exceeds Criteria
BH-103	PAH = 0.48 mg/kg	0-5	24	Exceeds ALARA
BH-112	Th-230 = 43.4 pCi/g	5-10	30	Exceeds Criteria
BH-118	Th-230 = 5.48 pCi/g	5-7	7	Exceeds ALARA
BH-120	PAH = 1.29 mg/kg	5-6	7	Exceeds ALARA
BH-122	PAH = 0.86 mg/kg	0-5	7	Exceeds ALARA

Borehole cores will be field scanned with a Geiger Mueller 44-9 Beta Gamma detector in an area with a representative low-background activity. Samples will be collected in 1-ft intervals as discrete samples. The 1-ft interval vertical bottom borehole samples from the ground surface to 15 ft below the surface will be analyzed for the chemical plant ROD COCs (Ref. 1) identified in Table 3-1. In addition, the first 1-ft to 2-ft interval in each pit bottom boring will be analyzed for VOCs and the first 1-ft to 2-ft interval from 4-01, 4-06, and 4-08 will be analyzed by the TCLP. The vertical bottom borehole samples collected below the 15 ft sample will be archived and possibly analyzed pending receipt of results from the upper intervals. All inclined and vertical berm borehole samples collected will be analyzed for the COCs identified in Table 3-1. A total of 43 1-ft sample intervals will be taken in borehole 4-30.

Exceptions to the complete analysis of COCs are made for boreholes 4-11, 4-13, and 4-14 as discussed in Section 7.2.2. These exceptions are made because these three boreholes are being drilled to supplement incomplete characterization of the earlier boreholes as discussed in Section 7.2.2.

7.2 Raffinate Pit 4 Phase 1 Vertical Boreholes

A total of 15 vertical boreholes is proposed (4-01 through 4-15). Of these, 11 on the relatively flat bottom area and one on top of the berm will be drilled using a drill rig with continuous sampler. Three holes will be hand augered on the inner slopes of the berms. Sample identifications are shown in Table 7-2.

TABLE 7-2 Raffinate Pit 4 Phase 1 Vertical Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
4-01	25	SO-396401-01 Thru SO-396401-25
4-02	21	SO-396402-01 Thru SO-396402-21
4-03	25	SO-396403-01 Thru SO-396403-25
4-04	25	SO-396404-01 Thru SO-39604-25
4-05	21	SO-396405-01 Thru SO-396405-21
4-06	24	SO-396406-01 Thru SO-396406-24
4-07	23	SO-396407-01 Thru SO-396407-23
4-08	21	SO-396408-01 Thru SO-396408-21
4-09	21	SO-396409-01 Thru SO-396409-21
4-10	28	SO-396410-01 Thru SO-396410-28
4-11	24	SO-396411-01 Thru SO-396411-24
4-12	8	SO-396412-01 Thru SO-396412-08
4-13	8	SO-396413-01 Thru SO-396413-08
4-14	9	SO-396414-01 Thru SO-396414-09
4-15	29	SO-396415-01 Thru SO-396415-29

(a) Borehole locations appear in Figure A-4

TABLE 7-2 Raffinate Pit 4 Phase 1 Vertical Borehole and Sample Identifications (Continued)

(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

7.2.1 Raffinate Pit 4 Phase 1 Bottom

Based on Mallinckrodt Chemical Works Drawing No. 44-385-05-002 titled Topography and Plan of Raffinate Pit, issued December 31, 1963, it appears that most of the area that is now the bottom of Raffinate Pit 4 was excavated to provide fill material for the berms. Therefore, the pit bottom, after sludge and sediments are removed, is assumed to be essentially the native-soil.

The 11 boreholes at the pit bottom (4-01 through 4-10 and 4-15) will be drilled to approximate depths ranging from 21 ft to 29 ft deep to the bedrock surface. Nine of the 11 boreholes were spaced uniformly to represent the fraction of the soil volume to be characterized. The location of boreholes 4-08, and 4-09 coincide with the general area of an old stream channel that existed before Raffinate Pit 4 was built. It is possible that the native soil in this channel contains more granular material that would be conducive to contaminant migration. Two of the boreholes (4-10 and 4-15) were biased in the north shelf area where sludge has been located.

7.2.2 Raffinate Pit 4 Phase 1 Berms

The earlier deep boreholes along the phase 1 portion of the berm were, for the most part, adequate to characterize this area. Additional boreholes will be drilled to supplement the earlier characterization. Justification for the additional boreholes is discussed below.

Table 7-1 indicates that of the six boreholes exceeding site ROD cleanup standards, three (BH-102, BH-103, and BH-112) were sampled to depths considerably greater then the depth at which the site cleanup standard was exceeded. For BH-102, samples deeper than 15 ft did not exceed lead requirements; therefore, no further sampling will be done. For BH-103, polycyclic aromatic hydrocarbons (PAHs) were not analyzed in samples from 5 ft to 20 ft deep; therefore, since archived samples are not valid for PAHs a new 24-ft deep borehole (4-11) is proposed.

Each 1-ft sample between the depths of 5 ft and 24 ft will be collected and analyzed for PAHs only. For BH-112, samples deeper than 10 ft did not exceed cleanup standards; therefore, no further sampling will be done.

Also from Table 7-1, since BH-118 exceeds thorium cleanup standards at the maximum 7 ft depth sampled, a new hand-augered borehole (4-14) is proposed to a 9 ft depth adjacent to BH-118. The two 1-ft samples between the depths of 7 ft and 9 ft will be collected and analyzed for Th-230 and Th-232 only. For BH-120, PAH cleanup standards were exceeded at the 5 ft to 6 ft interval, but were not analyzed at the 6 ft to 7 ft interval; therefore, a new 8-ft deep borehole (4-13) is proposed adjacent to BH-120. The two 1-ft samples between the depths of 6 ft and 8 ft will be collected and analyzed for PAHs only. For BH-122, PAHs met the cleanup standards 1 ft below the depth at which the As Low As Reasonably Achievable (ALARA) value was exceeded; therefore, no further sampling will be done.

One hand-augered borehole (4-12) will be drilled on the inner slope of the northwest berm because this area was not characterized in the 1995-96 sampling event.

7.3 Raffinate Pit 4 Phase 1 Inclined Boreholes

One inclined borehole (4-30) is proposed to further characterize the inner slope of the northwest berm. The location and geometry of the borehole are shown on Figure A-4. The borehole will be aligned with Borehole 4-12 so that the bottom of the inclined borehole will be vertically below the hand-augered borehole. The location of Borehole 4-30 will result in a sample that is approximately 21 ft deep at the slope location. Sample identifications are shown on Table 7-3.

TABLE 7-3 Raffinate Pit 4 Phase 1 Inclined Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
4-30	43	SO-396430-01 Thru SO-396430-43

(a) Borehole locations appear in Figure A-4.
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

8 RAFFINATE PIT 4-PHASE 2 SAMPLE LOCATIONS AND PARAMETERS

8.1 General

Pit 4 Phase 2 sampling will be in the area south of the proposed intermediate dike, after the sludge and natural sediments are dredged from this area. The general arrangement of Raffinate Pit 4 and the approximate borehole locations and depths for Phase 2 work are shown in Appendix A, Figure A-5. Final coordinates of boreholes will be surveyed following sampling.

The contour lines in Figure A-5 represent the clay surface beneath the sludge and natural sediments as presented in the *Raffinate Pit Characterization* report by ECO-Systems (Ref. 5). These contour lines are expected to change to some degree after the sludge and natural sediments are removed. Pit bottom borehole elevations in this report are preliminary, based on the ECO-Systems contour lines. These preliminary elevations will be confirmed and revised, as necessary, after dredging is completed. Final elevations will be surveyed following sampling.

Sample locations are grouped into the following three general categories: (1) vertical boreholes at raffinate pit bottom, (2) vertical boreholes at raffinate pit top of berms, and (3) inclined and vertical boreholes at raffinate pit berms inner slopes.

Sampling of sediments from exposed beach areas of Raffinate Pit 4 was conducted in February of 1996, (Sample Numbers C465 - C476). The sampling indicated that in all cases, polychlorinated biphenyls (PCBs) were less than 1 mg/kg, metals were below the potential to exceed toxicity characteristic leaching procedure (TCLP) values, semivolatiles were below detection limits, and volatile organic compounds (VOCs) were all below detection limits except acetone (0.16 mg/kg). The sampling also concluded that there is no indication of *Toxic Substance Control Act* (TSCA) or *Resource Conservation Recovery Act* (RCRA) characteristic contaminants at regulated levels within the black or brown sediments located along the exposed beach areas of Raffinate Pit 4.

Sampling of Raffinate Pit 4 berms was completed in late 1995 and early 1996 per an earlier sampling plan (Ref. 3); the sampling points are shown on Figure A-5. Based on the results of the 1995-96 sampling (Ref. 4) none of the samples exceeded the chemical plant Record of Decision (ROD) soil cleanup standards (Ref. 1). However, this earlier sampling did not include the southwest berm and the south berm; therefore, boreholes will be drilled in these areas in order to complete the characterization of the berms.

Borehole cores will be field scanned with a Geiger Mueller 44-9 Beta Gamma detector in an area with a representative low-background activity. Samples will be collected in 1-ft intervals as discrete samples. The 1-ft interval vertical bottom borehole samples from the ground surface to 15 ft below the surface will be analyzed for the chemical plant ROD COCs identified in Table 3-1 (Ref. 1). In addition, the first 1-ft to 2-ft interval in each pit bottom boring will be analyzed for VOCs and the first 1-ft to 2-ft interval from 4-01, 4-06, and 4-08 will be analyzed by the TCLP. The vertical bottom borehole samples collected below the 15-ft sample will be archived and possibly analyzed pending receipt of results from the upper intervals. All inclined and vertical berm borehole samples collected will be analyzed for the COCs identified in Table 3-1. A total of 61 1-ft sample intervals will be available in borehole 4-70.

8.2 Raffinate Pit 4 Phase 2 Vertical Boreholes

A total of 20 vertical boreholes is proposed (4-50 through 4-69). Of these, 11 on the relatively flat bottom areas and six on top of the berm will be drilled using a drill rig with continuous sampler. Three holes will be hand augered on the inner slopes of the berms. Sample identifications are given in Table 8-1.

TABLE 8-1 Raffinate Pit 4 Phase 2 Vertical Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
4-50	20	SO-300450-01 Thru SO-300450-20
4-51	20	SO-300451-01 Thru SO-300451-20
4-52	21	SO-300452-01 Thru SO-300452-21
4-53	18	SO-300453-01 Thru SO-300453-18
4-54	16	SO-300454-01 Thru SO-300454-16
4-55	24	SO-300455-01 Thru SO-300455-24
4-56	23	SO-300456-01 Thru SO-300456-23
4-57	19	SO-300457-01 Thru SO-300457-19
4-58	25	SO-300458-01 Thru SO-300458-25
4-59	36	SO-300459-01 Thru SO-300459-36
4-60	42	SO-300460-01 Thru SO-300460-42
4-61	38	SO-300461-01 Thru SO-300461-38
4-62	26	SO-300462-01 Thru SO-300462-26
4-63	19	SO-300463-01 Thru SO-300463-19
4-64	14	SO-300464-01 Thru SO-300464-14
4-65	12	SO-300465-01 Thru SO-300465-12

TABLE 8-1 Raffinate Pit 4 Phase 2 Vertical Borehole and Sample Identifications (Continued)

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
4-66	9	SO-300466-01 Thru SO-300466-09
4-67	8	SO-300467-01 Thru SO-300467-08
4-68	8	SO-300468-01 Thru SO-300468-08
4-69	8	SO-300469-01 Thru SO-300469-08

(a) Borehole locations appear in Figure A-5
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

8.2.1 Raffinate Pit 4 Phase 2 Bottom

Based on Mallinckrodt Chemical Works Drawing No. 44-385-05-002 titled Topography and Plan of Raffinate Pit, issued December 31, 1963, it appears that most of the area that is now the bottom of Raffinate Pit 4 was excavated to provide fill material for the berms. Therefore, the pit bottom, after sludge and sediments are removed, is essentially the native-soil.

The 11 boreholes at the pit bottom (4-50 through 4-60) will be drilled to approximate depths ranging from 16 ft to 42 ft deep to the bedrock surface. The bottom of this part of Raffinate Pit 4 is in two areas, one on each side of the proposed haul road. Boreholes 4-59 and 4-60 are located in the pit bottom area east of the haul road. These boreholes were located in or near the previously designated PCB area. The two pit bottom areas are at elevations lower than the historical high water level elevation of 652 ft. The boreholes in the pit bottom area west of the haul road were spaced uniformly to represent the fraction of the soil volume to be characterized.

8.2.2 Raffinate Pit 4 Phase 2 Berms

Six additional boreholes (4-61 through 4-66) will be drilled at the top of berm at approximately 664 ft elevation to characterize the southwest and south berms. The boreholes are located uniformly along the berm to supplement earlier characterization. These holes will range from approximately 9 ft deep to 38 ft deep to the native-soil fill interface; however, a final determination of the interface location will be made by the field geologist. When the native-soil fill interface is reached, two additional 1-ft samples will be collected.

Three boreholes (4-67 through 4-69) will be hand augered on the inner slopes of the berms to characterize the soil below the inner slope surfaces. The boreholes are positioned at approximately mid-slope along the southwest and south inner slopes. The eastern inner slope does not include any boreholes because the boreholes east of the haul road are deemed sufficient to characterize this area. Also, no boreholes are proposed on the intermediate dike because plans are to remove the entire dike, and the pit bottom sampling on both sides of the intermediate dike is sufficient characterization for this area.

8.3 Raffinate Pit 4 Inclined Borehole

One inclined borehole (4-70) is proposed to further characterize the inner slope of the southwest berm. The location and geometry of the borehole are shown on Figure A-5. The borehole will be aligned with Borehole 4-67 so that the bottom of the inclined borehole will be vertically below the hand-augered borehole. A drill rig with continuous sampler will be used. The location of Borehole 4-70 will result in a sample that is approximately 24 ft deep at the slope location. Sample identifications are shown in Table 8-2.

TABLE 8-2 Raffinate Pit 4 Phase 2 Inclined Borehole and Sample Identifications

BOREHOLE LOCATION ID[a]	NO. OF SAMPLE INTERVALS	SAMPLE ID[b]
4-70	61	SO-300470-01 Thru SO-300470-61

(a) Borehole location appears in Figure A-5.
(b) Each suffix of the sample ID denotes the sample sequence in the borehole beginning with the shallowest sample. Any variations to the IDs will be documented in the results report.

9 SAMPLE DESIGNATION AND CUSTODY

9.1 Sample Designation

Sample numbering will follow Procedure ES&H 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*. The specific sample identification numbers are detailed in Section 4. Sample forms from Procedure ES&H 4.4.5, *Soil/Sediment Sampling*, will be completed for each sample, with a minimum of the following information:

- Sample ID Number
- Location
- Date
- Time of collection
- Sample collection method
- Preservation
- Name(s) of sampler(s)

9.2 Chain-of-Custody Requirements

Chain-of-custody forms for laboratory samples will be completed and placed in the sample coolers. Sample coolers prepared for shipment will be sealed with chain-of-custody control seals signed and dated by the shipper. Chain-of-custody forms and seals will be prepared in accordance with Procedure ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody*.

10 SAMPLING EQUIPMENT AND COLLECTION METHODS

10.1 Sample Collection Procedures for Laboratory Analysis

Samples will be collected using a drill rig with a continuous sampler or with a hand auger. Shallow (less than 10 ft) borehole samples will be collected with a hand auger. Boring logs will be kept and boreholes will be backfilled and abandoned as specified in the subsurface investigations specification. Samples will be placed in glass or plastic sample containers as required for the specific parameters (Section 12.2). All samples requiring cooling will then be placed on ice in coolers while in the field. Sample labels will be completed and attached to all containers prior to placement in the coolers. Sample collection and labeling of containers will be in accordance with Procedures ES&H 4.4.5, *Soil/Sediment Sampling*, and ES&H 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*. Sample locations, samples collected, and related data will be recorded in a logbook, at the time of collection in accordance with Procedure ES&H 1.1.4, *Logbook Procedure*, and on the soil sampling data sheet as per ES&H 4.4.5, *Soil/Sediment Sampling*.

10.2 Sampling Procedures for Field Analyses

Soils will be visually examined and field notes will document any variations in the soils during sampling. All borings will be field scanned with a Gieger Mueller 44-9 Beta Gamma detector, and the readings will be noted in the logbook and/or soil/sediment field sheet. Scanning will be performed in a controlled environment with representative background.

If other field analyses are performed, then the sample location, type of information collected, and related information will also be recorded in the logbook in accordance with Procedure ES&H 1.1.4, *Logbook Procedure*, and/or on the soil/sediment sampling field sheet as per ES&H 4.4.5, *Soil/Sediment Sampling*.

10.3 Equipment Decontamination

Tools used to collect or transfer samples will be cleaned and decontaminated between each sample. Decontamination will be performed in accordance with Procedure ES&H 4.1.3, *Sampling Equipment Decontamination*. Decontamination waste will be handled per ECDI-17.

11 SAMPLE HANDLING AND ANALYSIS

11.1 Analytical Methods

Analytical methods will conform to the quantitative quality assurance (QA) parameters of precision, accuracy, and detection limit as specified in the *Scope of Work for Analytical Sources* (Ref. 9).

11.2 Preservation Methods and Sample Containers

Preservation methods and containers for samples will be in accordance with the requirements specified by the selected analytical methods. Table 12-1 details the requirements for each parameter.

11.3 Packaging Samples for Shipment and Transportation of Samples

When an off-site laboratory is used, samples will be packaged and transported to the laboratory in accordance with U.S. Department of Transportation Requirements, the *Site Consolidated Transportation Activity Manual* (Ref. 10), and Weldon Spring Site Remedial Action Project (WSSRAP) procedures. Samples will be shipped per ECDI-3 and returned per ECDI-5. A separate custody record must accompany each sample cooler or package.

Soil samples to be taken outside the controlled area will be scanned with a Geiger-Mueller gamma detector prior to leaving access control, and instrument readings will be recorded in accordance with Environmental Safety and Health procedures. This includes samples that are being sent to off-site laboratories and those that are being analyzed by immunoassay.

11.4 Sample Custody

Sample custody activities for sampling will be conducted in accordance with the sample custody program for the Weldon Spring site, which includes documentation of procedures for

TABLE 11-1 Sample Preservation and Collection Details

ANALYSIS (METHOD)	USE OF ON-SITE OR OFF-SITE LABORATORY	CONTAINER SIZE AND TYPE	PRESERVATIVE
As, Cr, Pb Tl (CLP)	Off-site	250 ml amber glass jar	N/A
PAH (SW 846) PCB (SW 846)	Off-site	500 ml amber glass jar	Cooled on ice
2,4,6-TNT (HPLC or GC)	Off-site	250 ml amber glass jar	Cooled on ice
U-238, Ra-226, Ra-228 (Gamma or Alpha Spectroscopy) Th-230, Th-232 (Alpha Spectroscopy)	On-site and/or off-site (depending upon on-site availability)	**ON-SITE:** plastic bag* **OFF-SITE:** 500 ml clear glass jar	N/A
VOC (CLP)[a]	Off-site	2-40 ml glass vials	Cooled on ice
Full TCLP (SW 846)[a] Metals, Semi Volatiles, VOA, Pesticides/PCBs	Off-site	VOA: 4-40 ml glass vials All others - 500 ml amber glass jar	Cooled on ice
WTCLP[a] Metals (Be, Mo, Tl, Zn) Rad (Uranium, isotope, thorium, isotope) Radium-226 and Radium-228 Anions (fluoride, nitrate, sulfate)	Off-site	500 ml amber glass jar	Cooled on ice

* On-site analysis requires a minimum of 500g dry soil.
N/A Not applicable.
PAHs: benzo (a) anthracene, benzo (b) fluoranthene, benzo (k) fluoranthene, benzo (a) pyrene, and chrysene and ideno (g,h,i-cd) pyrene
PCBs: Aroclor 1248, Aroclor 1254, and Aroclor 1260
(a) These analyses are to support other studies and investigations and are not part of this plan's study report.

the preservation of samples, sample identification, recording sample collection location, and specific considerations associated with sample acquisition. Applicable forms for recording these data, and the tracking of samples as required by chain-of-custody procedures, are specified in Procedures ES&H 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*; 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody*; 4.1.4, *Quality Control Samples of Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection Procedures*; and 4.4.5, *Soil/Sediment Sampling*.

Samples will be accompanied by chain-of-custody records. Completed chain-of-custody documents will be retained as QA records and maintained in accordance with the *Weldon Spring Site Remedial Action Project (WSSRAP) Quality Assurance Program* (Ref. 11).

Authorized sample custodians at the laboratory will sign for incoming samples, obtain documents of shipment, and verify data entered onto the sample custody records. If any damage or shipping discrepancy is noted upon receipt of samples, the laboratories will be required to inform the Project Management Contractor immediately.

11.5 Data Evaluation and Reduction

Data packages received from the subcontracted laboratory will undergo several processes to evaluate the quality of the data. When the data are received, the Verification Group will distribute a data verification review package to the data users. If validation of sample analysis has been requested, a copy will be forwarded to the Validation Group for data qualification.

11.5.1 Data Verification

All sample analytical results received from the laboratory will be reviewed in accordance with ES&H 4.9.1, *Environmental Monitoring Data Verification*. The following factors will be evaluated to verify if a sample has been properly handled according to WSSRAP protocol:

- Chain-of-custody
- Holding times
- Sample preservation requirements
- Laboratory chain-of-custody

- Sample analysis request form
- Quality Control samples
- Laboratory receipt forms

11.5.2 Data Review

Copies of the data packages will be distributed to the data users for their review. The data will be reviewed to identify discrepancies in the field quality control samples, inconsistencies with characterization data, and apparent abnormalities. Deficiencies reported by data users will be reported to the Verification Group. Data users may request validation of any data that appear to be of questionable quality. This review will be done in accordance with ES&H Procedure 4.9.3, *Data Review Procedure for Surface Water, Groundwater, and Soils.*

11.5.3 Data Validation

Randomly selected laboratory data and data selected by verification or data users will undergo thorough reviews of the analytical process in accordance with ES&H 4.9.2, *Environmental Monitoring Data Validation*. These reviews will be conducted by the Validation Group. Ten percent of laboratory data associated with this plan will be validated.

The purpose of this validation procedure will be to specify a consistent means for reviewing and evaluating the data resulting from laboratory analyses and for providing a consistent means of documenting the evaluations and reporting the usefulness of the data to the data users. This will be accomplished through a thorough review of the analytical data using laboratory analytical records to assess laboratory conformance to quality control criteria, data quality requirements for data quality objectives, and procedural requirements.

12 QUALITY ASSURANCE

MK-Ferguson Company, the Project Management Contractor (PMC) at the Weldon Spring Site Remedial Action Project (WSSRAP), has developed the *Project Management Contractor Quality Assurance Program* (QAP) in accordance with DOE Order 5700.6C. The *Project Management Contractor (PMC) Quality Assurance Program* (QAP) (Ref. 11) applies a graded approach to ensure that activities performed at the WSSRAP are of documented quality.

The QAP is supported by site quality procedures that direct the evaluation of quality-affecting activities by implementing independent assessments and processes to identify nonconforming conditions and to ensure corrective actions.

The PMC has developed the *Environmental Quality Assurance Project Plan* (Ref. 12) to guide all environmental activities conducted at the WSSRAP in accordance with U.S. Environmental Protection Agency guide lines.

12.1 Analytical Procedures

The on-site or off-site quantitative laboratory conducting radiological and chemical analysis for the samples have submitted controlled copies of its site-specific quality assurance project plans (QAPjP) and standard operating procedures (SOPs). These plans and SOPs have been reviewed and accepted by the PMC. The WSSRAP and contract laboratory SOPs direct the operations, analyses, and activities that will be thoroughly prescribed, documented, and performed in accordance with accepted standards and methodologies. Any changes to controlled SOPs and the QAPjP are reviewed by the PMC. The laboratory QAPjP and SOPs specify quality control requirements to demonstrate the precision and accuracy of methods and procedures.

All data generated by analytical activities (i.e., calculations, chromatographs, calibration curves, quality assurance analyses) are QA records and will be maintained in accordance with the PMC QAP.

Maintenance and storage of completed records, charts, and logs of all pertinent calibrations, analyses, quality control activities, and data generated by the laboratory will be kept in a WSSRAP-specific project file. Both electronic and hard-copy data reports must be available at the laboratory's facilities for 3 years after termination or expiration of any contract. Storage areas must keep records safe from damage by moisture or fire.

12.2 Internal Quality Control Checks

Quality control samples will be collected to ensure consistent and accurate performance of sample collection and laboratory analysis. Table 12-1 provides a summary list of the quality control samples that will be collected to support the final survey.

TABLE 12-1 Field Quality Control Sample Summary

QUALITY CONTROL SAMPLE TYPE	FREQUENCY	PURPOSE
Matrix Spike/Matrix Spike Duplicate or Matrix Duplicate	1 per 20 or 1 per 14 days[a]	Assess matrix and possible interlaboratory variability
Field Replicate	1 per 20	Assess matrix and interlaboratory variability
Equipment Blank (nondedicated equipment only)	1 per 20	Assess effectiveness of decontamination
Deionized Water Blank[b]	1 per month	Assess quality of deionized water
Field/Trip Blank[b]	1 for each VOC shipment	Assess impact of ambient conditions on samples

(a) Whichever is of higher frequency.
(b) Collected together on the same day.

12.2.1 Quality Assurance Records

Records generated as a result of this plan will be maintained as QA records. Field sampling forms, analytical data, equipment calibration records, and confirmation and validation documentation records will all be considered QA records and will be maintained in accordance with the requirements of SQP-7, *Quality Assurance Records*. This will provide both security and protection tó critical records.

13 REFERENCES

1. U.S. Department of Energy, Oak Ridge Field Office. *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Sprint Site*, DOE/OR/21548-376. Oak Ridge, Tennessee. September 1993.

2. MK-Ferguson Company and Jacobs Engineering Group. *Sample Management Guide*, Revision 0. DOE/OR/21548-499. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. March 1995.

3. MK-Ferguson Company and Jacobs Engineering Group. *Engineering Soil Sampling for the Weldon Spring Chemical Plant and Raffinate Pit Berms*, Revision 1. DOE/OR/21548-576. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. February 1996.

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6. MK-Ferguson Company. *Waste Assessment Chemical Characterization of the Weldon Spring Raffinate Pits*, Rev. 0. DOE/OR/21548-092. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, St. Charles, Missouri. August 1989.

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9. *Scope of Work for Analytical Sources*, Rev. 0, Contract No. DE-AC05-86OR21548. Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri. April 1996.

10. MK-Ferguson Company and Jacobs Engineering Group. *Site Consolidated Transportation Activity Manual*, Rev. 0. DOE/OR/21548-309. Prepared for the U.S. Department of Energy, Oak Ridge Field Office. St. Charles, Missouri. October 1992.

11. MK-Ferguson Company and Jacobs Engineering Group. *Project Management Contractor Quality Assurance Program*, Rev. 2. DOE/OR/21548-333. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. December 1995.

12. MK-Ferguson Company and Jacobs Engineering Group. *Environmental Quality Assurance Project Plan*, Rev. 2. DOE/OR/21548-352. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. May 1993.

PROCEDURES

ES&H 1.1.4, *Logbook Procedure*
ES&H 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*
ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody*
ES&H 4.1.3, *Sampling Equipment Decontamination*
ES&H 4.1.4, *Quality Control Samples of Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection*
ES&H 4.4.5, *Soil/Sediment Sampling*
ES&H 4.9.1, *Environmental Monitoring Data Verification*
ES&H 4.9.2, *Environmental Monitoring Data Validation*
ES&H 4.9.3, *Data Review Procedure for Surface Water, Groundwater, and Soils*
RC-17, *Off-Site Transportation of Hazardous Materials*

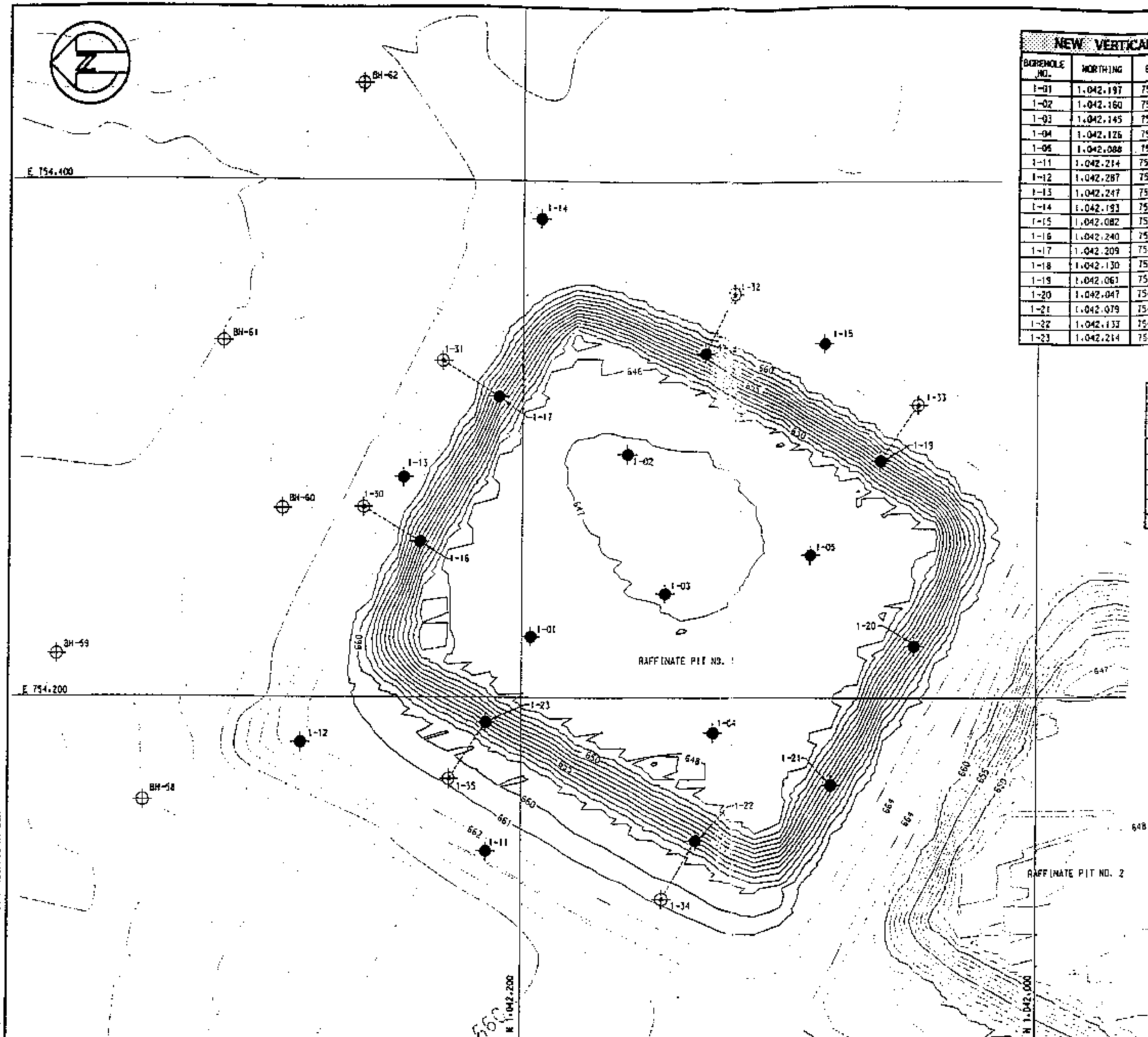
SQP-7, *Quality Assurance Records*
ECDI-3, *Hazardous Material/Sample Transportation Activity (HMSTA) Operations*
ECDI-5, *Management of Samples Returned to the Weldon Sprint Site*
ECDI-17, *Handling and Disposition of Site Generated Wastes*

DOE ORDERS

5700.6C, *Quality Assurance Program a Total Management System*

APPENDIX A
Raffinate Pits Sample Location Figures

APPENDIX A
CONTENTS



NEW VERTICAL BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
1-01	1,042,197	754,224	648	30
1-02	1,042,160	754,295	647	29
1-03	1,042,145	754,240	647	29
1-04	1,042,126	754,187	648	30
1-05	1,042,088	754,255	647	29
1-11	1,042,214	754,148	664	22
1-12	1,042,287	754,193	664	22
1-13	1,042,247	754,286	664	22
1-14	1,042,193	754,385	664	22
1-15	1,042,082	754,338	655	22
1-16	1,042,240	754,250	655	8
1-17	1,042,209	754,317	655	8
1-18	1,042,130	754,334	655	8
1-19	1,042,061	754,292	655	8
1-20	1,042,047	754,220	655	8
1-21	1,042,079	754,157	655	8
1-22	1,042,133	754,145	655	8
1-23	1,042,214	754,190	655	8

EARLIER BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
BH-58 *	1,042,347.7	754,160.3	653.2	5
BH-59	1,042,382.1	754,216.5	652.7	2.5
BH-60	1,042,294.2	754,273.5	657.5	5
BH-61	1,042,317.3	754,338.0	660.5	5
BH-62	1,042,263.0	754,437.0	660.3	5

* EARLIER SAMPLING INDICATED CONTAMINANTS EXCEEDING CLEANUP STANDARDS

NEW INCLINED BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	ANGLE (°)	ELEV TOP/BOT	DEPTH @ SLOPE (FT)	HOLE LENGTH (FT)
1-30	1,042,262	754,274	45	664/638	17	37
1-31	1,042,232	754,330	45	664/638	17	37
1-32	1,042,118	754,357	45	664/638	17	37
1-33	1,042,046	754,314	45	664/638	17	37
1-34	1,042,146	754,123	45	661/634	21	39
1-35	1,042,229	754,169	45	661/634	21	39

LEGEND

BH-58 EARLIER BOREHOLE AND NO.

1-01 NEW VERTICAL BOREHOLE AND NO.

1-30 NEW INCLINED BOREHOLE AND NO.

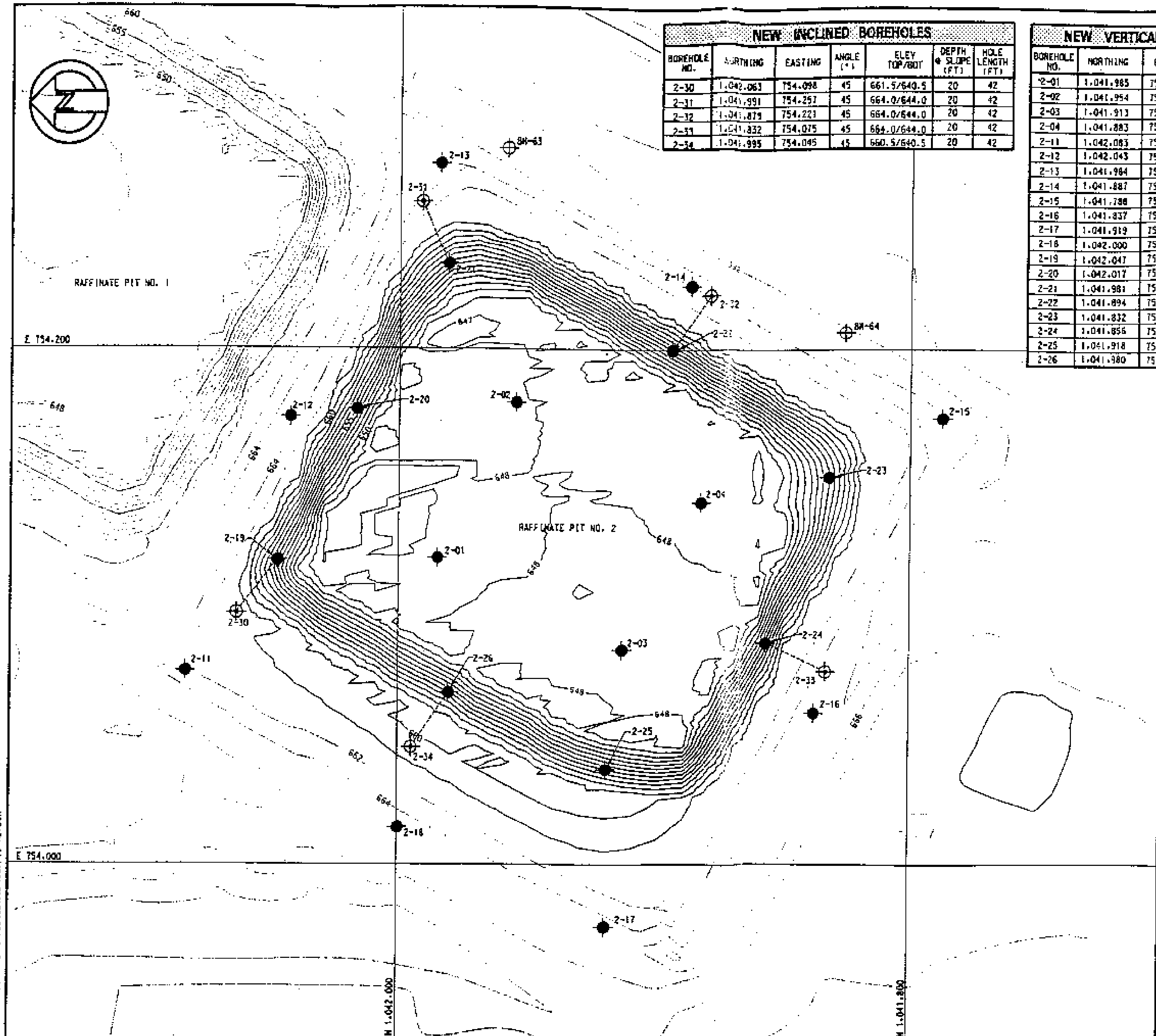
0 10 20 40 60 80 100 FT

SCALE: 1" = 40'-0"

RAFFINATE PIT 1 SAMPLE LOCATIONS

FIGURE A-1

REPORT NO.: DOE/OR/2148-653	EXHIBIT NO.: B/RP/001/1096	
CATEGORY: IEJ	DRAWN BY: KSR	DATE: 10/07/96



NEW INCLINED BOREHOLES						
BOREHOLE NO.	NORTHING	EASTING	ANGLE (°)	ELEV TOP/BOT	DEPTH @ SLOPE (FT)	HOLE LENGTH (FT)
2-30	1,042.063	754.098	45	661.5/640.5	20	42
2-31	1,041.991	754.257	45	664.0/644.0	20	42
2-32	1,041.879	754.223	45	664.0/644.0	20	42
2-33	1,041.832	754.075	45	664.0/644.0	20	42
2-34	1,041.995	754.045	45	660.5/640.5	20	42

NEW VERTICAL BOREHOLES				
BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
2-01	1,041.985	754.[illegible]	648	30
2-02	1,041.954	754.[illegible]	648	30
2-03	1,041.913	754.[illegible]	648	30
2-04	1,041.883	754.[illegible]	648	30
2-11	1,042.083	754.[illegible]	664	22
2-12	1,042.043	754.[illegible]	664	22
2-13	1,041.984	754.[illegible]	664	22
2-14	1,041.887	754.[illegible]	664	22
2-15	1,041.788	754.173	664	22
2-16	1,041.837	754.069	663	22
2-17	1,041.919	754.376	664	22
2-18	1,042.000	754.014	664	22
2-19	1,042.047	754.118	655	8
2-20	1,042.017	754.172	655	8
2-21	1,041.981	754.233	655	8
2-22	1,041.894	754.200	655	8
2-23	1,041.832	754.150	655	8
2-24	1,041.856	754.086	655	8
2-25	1,041.918	754.037	655	8
2-26	1,041.980	754.056	655	8

EARLIER BOREHOLES				
BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
BH-63	1,041.957.8	754.277.7	661.2	8
BH-64*	1,041.825.7	754.206.7	661.2	8

* EARLIER SAMPLING INDICATED CONTAMINANTS EXCEEDING CLEANUP STANDARDS

LEGEND

BH-63 EARLIER BOREHOLE AND NO.

2-01 NEW VERTICAL BOREHOLE AND NO.

2-30 NEW INCLINED BOREHOLE AND NO.

RAFFINATE PIT 2
SAMPLE LOCATIONS

FIGURE A-2

REPORT NO.: DOE/OR/2148-653	EXHIBIT NO.: B/RP/002/1096	
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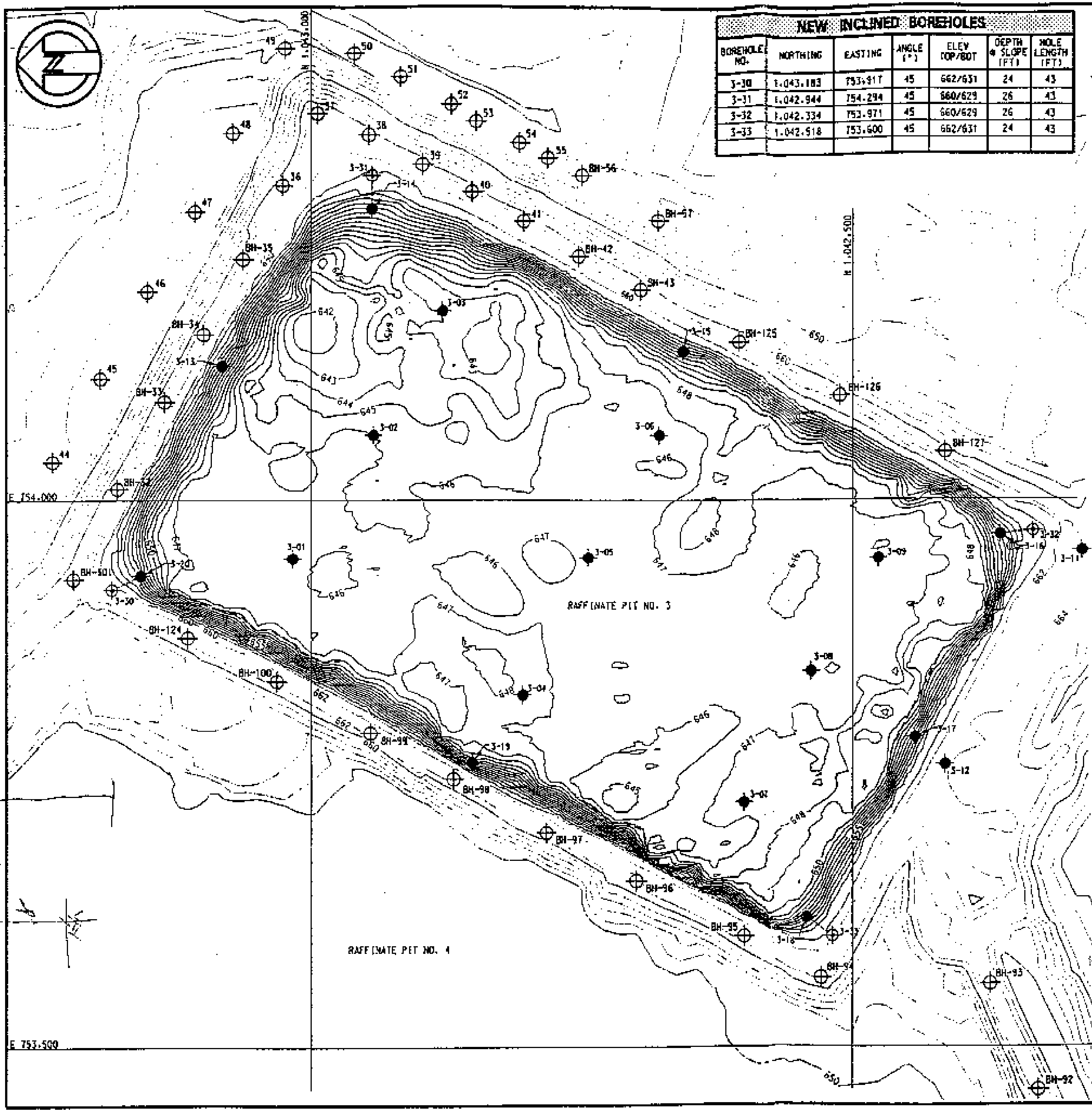


NEW INCLINED BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	ANGLE (°)	ELEV TOP/BOT	DEPTH @ SLOPE (FT)	HOLE LENGTH (FT)
3-30	1,043,183	753,917	45	662/631	24	43
3-31	1,042,944	754,294	45	660/629	26	43
3-32	1,042,334	753,971	45	660/629	26	43
3-33	1,042,518	753,600	45	662/631	24	43

NEW VERTICAL BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	ELEV	DEPTH (FT)
3-01	1,043,017	753,[illegible]	646	30
3-02	1,042,943	754,[illegible]	646	36
3-03	1,042,879	754,[illegible]	644	34
3-04	1,042,804	753,[illegible]	648	38
3-05	1,042,744	753,[illegible]	647	37
3-06	1,042,679	754,[illegible]	647	35
3-07	1,042,602	753,[illegible]	647	37
3-08	1,042,539	753,[illegible]	647	37
3-09	1,042,477	753,[illegible]	647	35
3-11	1,042,290	753,[illegible]	662	22
3-12	1,042,414	753,[illegible]	662	22
3-13	1,043,082	754,[illegible]	655	8
3-14	1,042,944	754,[illegible]	655	8
3-15	1,042,657	754,136	655	8
3-16	1,042,364	753,[illegible]	655	8
3-17	1,042,442	753,[illegible]	655	8
3-18	1,042,543	753,[illegible]	655	8
3-19	1,042,851	753,760	655	8
3-20	1,043,156	753,[illegible]	655	8

EARLIER BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	ELEV	DEPTH (FT)
BH-32*	1,043,177.6	754,010.1	663.1	23
BH-33	1,043,133.8	754,089.5	663.3	28
BH-34*	1,043,098.0	754,151.0	663.1	32
BH-35*	1,043,062.0	754,218.9	662.7	31
36	1,043,026.0	754,285.0	663.2	30
37*	1,042,994.0	754,350.0	663.2	29
38	1,042,946.8	754,330.6	663.1	28.7
39*	1,042,897.0	754,304.2	662.7	28
40	1,042,851.3	754,279.4	662.6	27
41	1,042,803.4	754,253.3	662.5	25.7
BH-42	1,042,752.1	754,221.9	663.1	17
BH-43	1,042,695.7	754,191.9	663.5	14
44	1,043,238.1	754,035.1	645.6	5
45	1,043,193.7	754,110.7	646.8	7
46	1,043,149.4	754,189.7	646.4	7
47	1,043,105.7	754,261.1	646.8	6
48	1,043,071.0	754,332.0	644.9	7
49	1,043,023.8	754,409.2	640.3	7
50	1,042,960.0	754,405.0	642.2	7
51	1,042,917.3	754,383.3	642.0	7
52	1,042,870.7	754,358.4	641.8	7
53	1,042,847.6	754,342.9	642.9	5
54*	1,042,807.5	754,324.0	642.2	7
55	1,042,781.2	754,310.5	642.5	7
BH-56	1,042,749.2	754,294.3	643.3	17
BH-57	1,042,679.6	754,254.2	645.0	17
BH-92	1,042,328.8	753,461.3	665.2	15
BH-93	1,042,372.4	753,556.8	665.1	17
BH-94	1,042,529.0	753,562.3	662.9	16
BH-95	1,042,601.7	753,600.5	663.7	20.5
BH-96	1,042,699.3	753,651.3	663.5	22
BH-97	1,042,782.0	753,695.1	663.5	26
BH-98	1,042,868.2	753,744.9	663.5	27
BH-99	1,042,945.5	753,786.3	663.4	22
BH-100	1,043,031.6	753,833.0	663.7	18
BH-101	1,043,218.6	753,926.7	662.7	25
BH-124	1,043,112.7	753,872.8	663.9	17
BH-125*	1,042,607.1	754,145.0	663.6	19
BH-126	1,042,512.2	754,095.3	663.8	19
BH-127	1,042,414.8	754,045.5	663.6	14

* EARLIER SAMPLING INDICATED CONTAMINANTS EXCEEDING CLEANUP STANDARDS

LEGEND

BH-32 EARLIER BOREHOLE AND NO.

3-01 NEW VERTICAL BOREHOLE AND NO.

3-30 NEW INCLINED BOREHOLE AND NO.

0FT 50 100 200 300FT

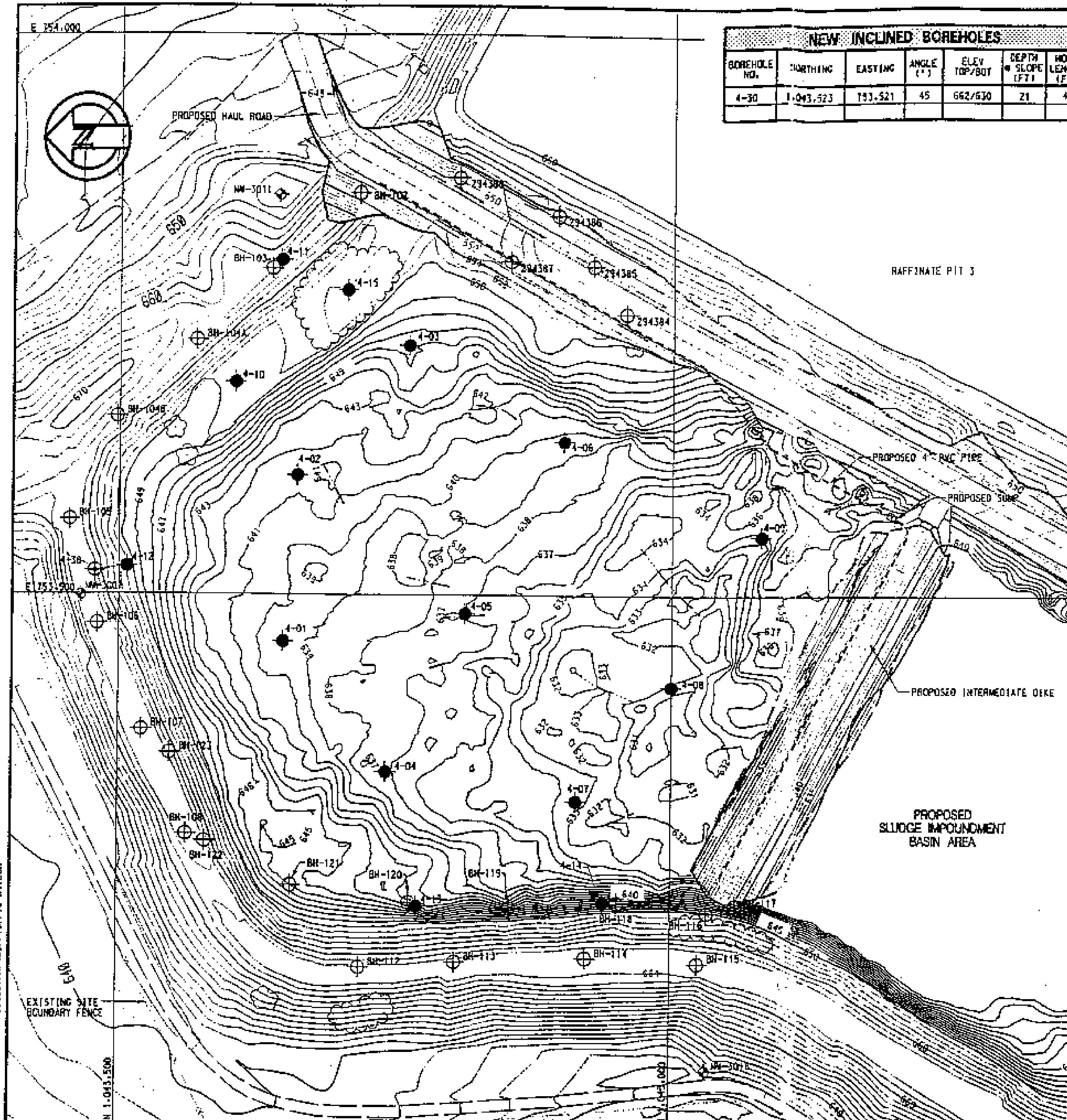
SCALE: 1" = 100'-0"

RAFFINATE PIT 3
SAMPLE LOCATIONS

FIGURE A-3

REPORT NO.: DOE/OR/2148-653	EXHIBIT NO.: B/RP/003/1096
CHECKED BY: IEJ	DRAWN BY: KSR	DATE: 10/07/96

FILENAME: 384001/RP480/FIG/FIG-A4.DGN



NEW INCLINED BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	ANGLE (°)	ELEV TOP/BOT	DEPTH @ SLOPE (FT)	HOLE LENGTH (FT)
4-30	1,043,523	753,521	45	662/630	21	43

NEW VERTICAL BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
4-01	1,043,352	753,458	[illegible]	25
4-02	1,043,340	753,607	[illegible]	21
4-03	1,043,240	753,724	[illegible]	25
4-04	1,043,258	753,342	[illegible]	25
4-05	1,043,188	753,484	[illegible]	21
4-06	1,043,098	753,638	[illegible]	24
4-07	1,043,086	753,316	[illegible]	23
4-08	1,043,001	753,418	[illegible]	21
4-09	1,042,922	753,553	[illegible]	21
4-10	1,043,396	753,691	[illegible]	28
4-11	1,043,355	753,800	[illegible]	24
4-12	1,043,493	753,525	[illegible]	8
4-13	1,043,230	753,222	[illegible]	9
4-14	1,043,061	753,225	[illegible]	9
4-15	1,043,295	753,774	[illegible]	29

EARLIER BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
BH-102*	1,043,284.5	753,859.2	664.2	23
BH-103*	1,043,363.1	753,792.4	663.5	24
BH-104A	1,043,430.6	753,729.0	662.9	27
BH-104B	1,043,502.5	753,660.0	663.3	27
BH-105	1,043,546.2	753,567.5	662.8	27
BH-106	1,043,520.0	753,474.1	665.2	30
BH-107	1,043,478.8	753,378.8	665.6	29.5
BH-108	1,043,437.7	753,285.3	664.6	31
BH-112*	1,043,281.5	753,166.6	660.1	30
BH-113	1,043,194.9	753,171.5	660.6	32
BH-114	1,043,075.9	753,175.0	665.2	39
BH-115	1,042,976.1	753170.5	665.6	48.5
BH-116	1,042,968.2	753,215.4	648.9	29
BH-117	1,042,943.1	753,222.0	644.3	7
BH-118*	1,043,048.0	753,225.0	644.4	7
BH-119	1,043,145.2	753,219.8	644.0	7
BH-120*	1,043,236.9	753,225.0	643.3	7
BH-121	1,043,344.0	753,240.0	648.6	7
BH-122*	1,043,421.0	753,279.0	662.9	7
BH-123	1,043,453.0	753,358.0	663.6	7
294384*	1,043,042.4	753,753.4	653.53	5
294385*	1,043,072.1	753,795.6	655.27	5
294386*	1,043,104.4	753,839.7	656.45	5
294387*	1,043,147.6	753,799.4	655.50	5
294388*	1,043,200.0	753,872.9	655.17	5

* EARLIER SAMPLING INDICATED CONTAMINANTS EXCEEDING CLEANUP STANDARDS.

LEGEND

BH-102 EARLIER BOREHOLE AND NO.

4-01 NEW VERTICAL BOREHOLE AND NO.

4-30 NEW INCLINED BOREHOLE AND NO.

MW-3011 EXISTING MONITORING WELL

0 50 100 200 300 FT

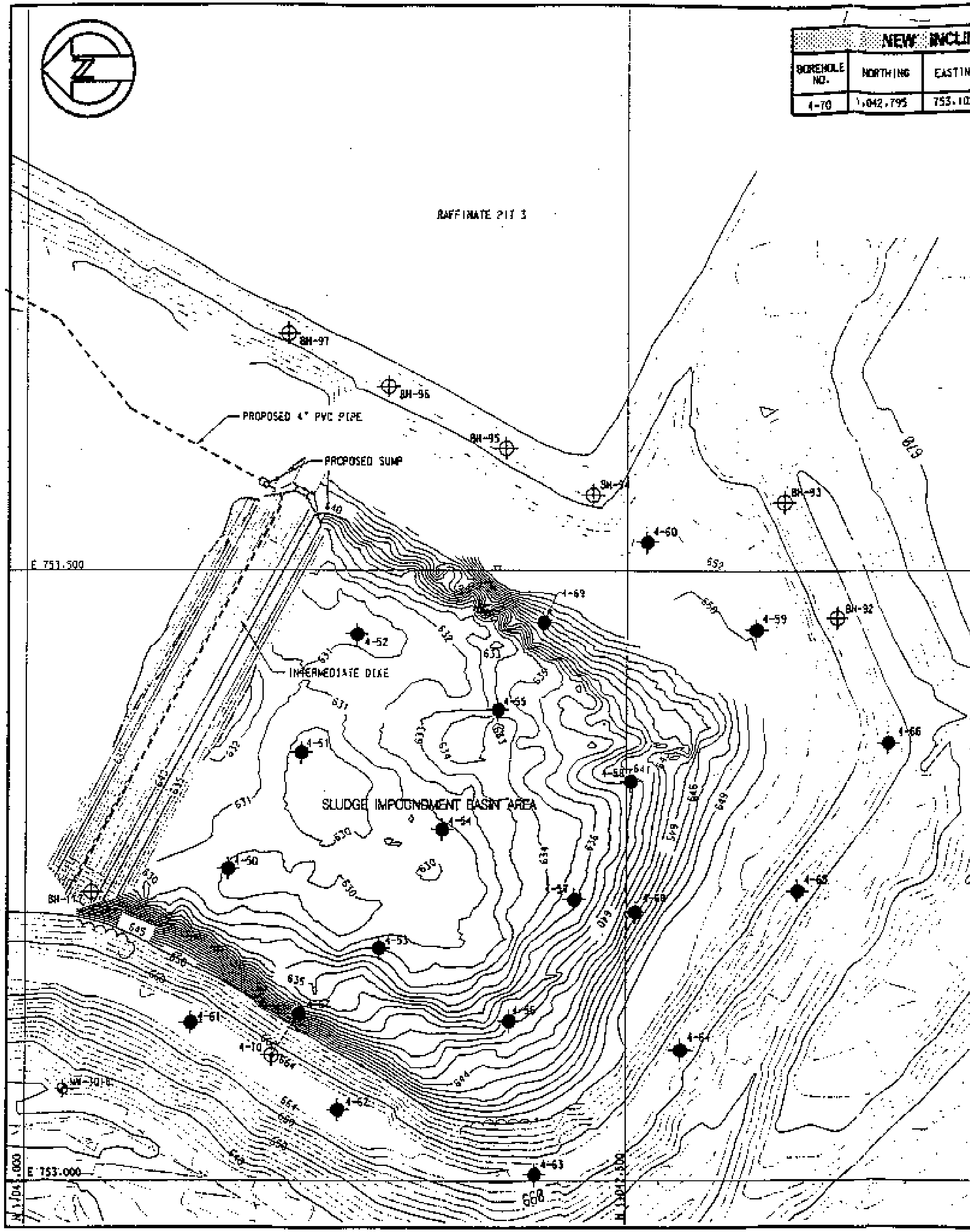
SCALE: 1" = 100'-0"

RAFFINATE PIT 4 - PHASE 1 SAMPLE LOCATIONS

FIGURE A-4

REPORT NO.: DOE/OR/2148-653		EXHIBIT NO.: B/RP/004/1096	
ORIGINATOR: IEJ	DRAWN BY: KSR	DATE: 10/10/96	

FILENAME: O:/384001/RP480/FIG-A5.DGN 10/09/96



NEW INCLINED BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	ANGLE (°)	ELEV TOP/BOT	DEPTH @ SLOPE (FT)	HOLE LENGTH (FT)
4-70	1,042,795	753,102	45	664/621	24	61

NEW VERTICAL BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
4-50	1,042,830	753,25[illegible]	630	20
4-51	1,042,771	753,35[illegible]	630	20
4-52	1,042,725	753,44[illegible]	631	21
4-53	1,042,706	753,18[illegible]	632	18
4-54	1,042,654	753,28[illegible]	631	16
4-55	1,042,608	753,38[illegible]	634	24
4-56	1,042,598	753,13[illegible]	641	23
4-57	1,042,543	753,22[illegible]	636	19
4-58	1,042,497	753,32[illegible]	640	25
4-59	1,042,394	753,45[illegible]	651	36
4-60	1,042,483	753,52[illegible]	652	42
4-61	1,042,861	753,12[illegible]	664	38
4-62	1,042,740	753,06[illegible]	664	26
4-63	1,042,576	753,005	664	19
4-64	1,042,455	753,107	664	14
4-65	1,042,361	753,236	664	12
4-66	1,042,284	753,3[illegible]	644	9
4-67	1,042,772	753,136	643	8
4-68	1,042,493	753,219	644	8
4-69	1,042,569	753,457	643	8

EARLIER BOREHOLES

BOREHOLE NO.	NORTHING	EASTING	TOP ELEV	DEPTH (FT)
BH-92	1,042,328.8	753,461.3	665.2	15
BH-93	1,042,372.4	753,556.8	665.1	17
BH-94	1,042,529.0	753,562.3	662.9	16
BH-95	1,042,601.7	753,600.5	563.7	20.5
BH-96	1,042,699.3	753,651.3	663.5	22
BH-97	1,042,782.0	753,695.1	663.5	26
BH-117	1,042,943.1	753,222.0	644.3	7

LEGEND

BH-92 EARLIER BOREHOLE AND NO.

4-50 NEW VERTICAL BOREHOLE AND NO.

4-70 NEW INCLINED BOREHOLE AND NO.

0ft 50 100 200 300ft

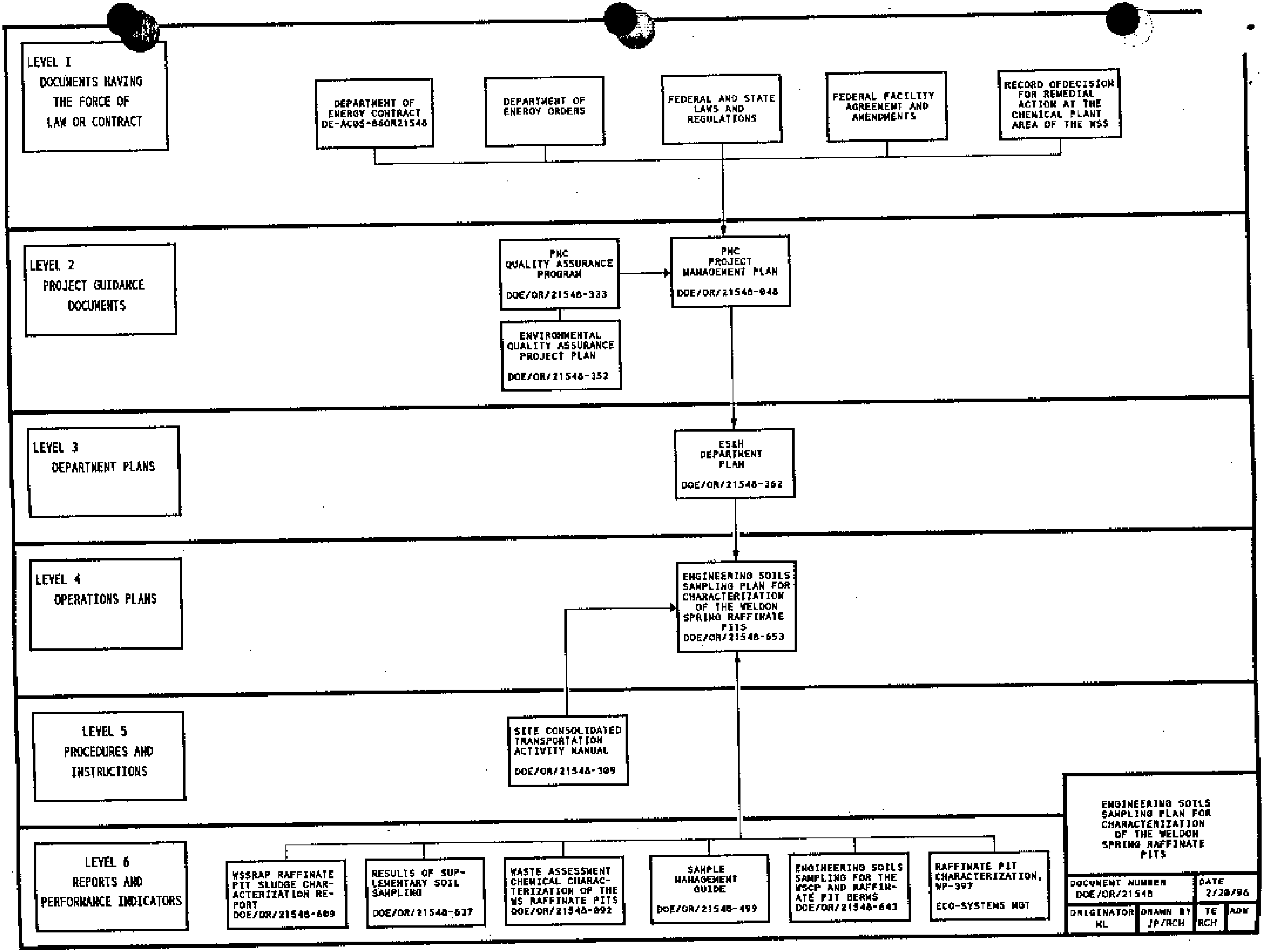
SCALE: 1" = 100'-0"

RAFFINATE PIT 4 - PHASE 2 SAMPLE LOCATIONS

FIGURE A-5

REPORT NO.: DOE/OR/2148-653		EXHIBIT NO.: B/RP/005/1096	
ORIGINATOR: IEJ	DRAWN BY: KSR		DATE: 10/08/96

APPENDIX B
Document Hierarchy


LEVEL I
DOCUMENTS HAVING THE FORCE OF LAW OR CONTRACT
DEPARTMENT OF ENERGY CONTRACT DE-AC05-86OR21548
DEPARTMENT OF ENERGY ORDERS
FEDERAL AND STATE LAWS AND REGULATIONS
FEDERAL FACILITY AGREEMENT AND AMENDMENTS
RECORD OF DECISION FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WSS
LEVEL 2
PROJECT GUIDANCE DOCUMENTS
PMC QUALITY ASSURANCE PROGRAM DOE/OR/21548-333
PMC PROJECT MANAGEMENT PLAN DOE/OR/21548-048
ENVIRONMENTAL QUALITY ASSURANCE PROJECT PLAN DOE/OR/21548-352
LEVEL 3
DEPARTMENT PLANS
ES&H DEPARTMENT PLAN DOE/OR/21548-362
LEVEL 4
OPERATIONS PLANS
ENGINEERING SOILS SAMPLING PLAN FOR CHARACTERIZATION OF THE WELDON SPRING RAFFINATE PITS DOE/OR/21548-653
LEVEL 5
PROCEDURES AND INSTRUCTIONS
SITE CONSOLIDATED TRANSPORTATION ACTIVITY MANUAL DOE/OR/21548-309
LEVEL 6
REPORTS AND PERFORMANCE INDICATORS
WSSRAP RAFFINATE PIT SLUDGE CHARACTERIZATION REPORT DOE/OR/21548-609
RESULTS OF SUPPLEMENTARY SOIL SAMPLING DOE/OR/21548-537
WASTE ASSESSMENT CHEMICAL CHARACTERIZATION OF THE WS RAFFINATE PITS DOE/OR/21548-092
SAMPLE MANAGEMENT GUIDE DOE/OR/21548-499
ENGINEERING SOILS SAMPLING FOR THE WSCP AND RAFFINATE PIT BERMS DOE/OR/21548-643
RAFFINATE PIT CHARACTERIZATION, WP-397 ECO-SYSTEMS MGT
ENGINEERING SOILS SAMPLING PLAN FOR CHARACTERIZATION OF THE WELDON SPRING RAFFINATE PITS
DOCUMENT NUMBER DOE/OR/21548
DATE 2/28/96
ORIGINATOR KL
DRAWN BY JP/RCH
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ADM